The long-term effects of the historical Roman road network: Trade costs of Italian provinces

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Abstract

This paper explores the connection between current trade costs and the historical Roman road network for the sample of 107 Italian NUTS3 provinces, checking for geographical, weather and historical measures. Italy represents a perfect study case for two reasons. First, Italian contemporary territory was completely under the Roman empire and almost all provinces (108 out of 110) include Roman roads within their area. Second, Italy is characterized by a lasting duality between the economically developed North-Centre and the less developed South. The main idea relates to the recent literature about how history has persistently affected, via existing institutions, actual economic outcomes. This is done by calculating for each Italian Province a specific measure on Roman roads intensity and testing whether differences on contemporary trade costs between provinces can be brought back to the long lasting impact of the Roman road system. Our results suggest that having an integrated system of roads, as it was during the Roman domination, plays an important role on the current trade. Provinces with a large Roman road network are more prone on having less trade costs, and therefore tend to trade more abroad than with themselves, according to the 'top-down' approach (Novy, 2013). On the whole, this study confirms not only the importance of history on the contemporary economic development, through past better institution, but also the main role of history on shaping a more open mentalité of peoples.

Keywords

Trade costs; Roman roads; History; Persistence; Italy; Provinces.

JEL Classification

F10; F14

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"And what was said by Homer, 'The Earth was common to all', you (Rome) have made a reality, by surveying the whole inhabited world, by bridging rivers, by cutting carriage roads through the mountains, by filling deserts with stationes, and by civilising everything with your way of life and good order"
Aelius Aristides *Orat.*26.101

1. Introduction

Adding to the recent literature on the persistent effect of history (and historical institutions) on present outcomes, this paper investigates the impact of the existence of old Roman roads on current trade costs. The main goal is to assess whether a stronger presence of ancient Roman roads is associated to a contemporary higher propensity to trade with foreign countries than internally. On the one hand this paper aims to validate a lasting impact of history on current economic results. On the other hand, it seeks to investigate whether the old Roman infrastructure left a mark on the present infrastructure. Good infrastructures are one of the most important determinants of lower trade costs and public investments in transportation infrastructure are considered a fundamental policy to boost exports. Along these lines, the paper presents one of the first investigations on the effect of the Roman empire and its network system.

Contributions on this subject are very recent and are represented by the works of Wahl (2015) and Dalgaard et al. (2015). According to Wahl (2015) the distinction between a Western developed Germany, crossed by an integrated Roman road system, and a less advanced (compared to the West) Eastern Germany originates from the division in ancient times between a Roman and non-Roman part. Using the nightlight luminosity, Wahl shows that the Roman Limes border wall, which divided the Roman German part from the non-Roman one, represents the boundary in the economic development of actual Germany. Likewise, employing the lights intensity, Dalgaard et al. (2015) find a long-run causal effect of Roman roads on economic development. These specific studies fit into the late nineties - early two thousands literature on institutions and lower economic development. Acemoglu et al. (2001, 2002), Nunn (2009), La Porta et al. (1999, 2008) have shown differences in productivity and per-capita gross domestic product (GDP) as long-term consequences of history and better/worst historical institutions, via existing institutions.

Focusing on trade issues, De Benedictis and Pinna (2015) show how geographical features determined participation to historical trade routes between 1750 and 1850 shaping openness and connectedness. They use islands as a natural experiment in order to evaluate the influence on trade costs from geography and historical events: once geographical features (and physical distance) have been taken as given, the other factor that contributes in build connectedness can be retrieved in history.

Volpe Martincus et al. (2014) investigate whether public policies promoting investments in transportation infrastructure have a positive effect on firms' exports. Using the Inca road network (built by the Inca empire before 1530) as an instrument for the current road infrastructure in Peru, they find that improvements in road networks lead advantage to firms' exporting activity and job growth.

Recent literature (Donaldson, 2012) has also revealed interest in the effect of history’s great transportation infrastructure projects on reducing trade costs, on playing a positive impact on productivity and on increasing the level of real income in trading regions. Using data from colonial India, he investigates the impact of India's railroad network.

The effect of historical transportation infrastructure is characterized by a potential simultaneity problem: roads and railways are often constructed to connect already active trade regions while trade relationships between regions often emerge after the construction of infrastructures or road improvements. On this view, it can be argued that the relation between the existence of Roman roads and a higher propensity to trade suffers from an endogeneity problem. Looking at Roman empire this is less likely to be the case, for two reasons: military and engineering. The purpose to build roads was always militaristic: they were constructed for war campaigns. The military spirit of the Roman public road system was clearly reflected in its aim: to unite and consolidate the conquests of the Roman people, whether within or without the limits of Italy proper (Dictionary of Greek and Roman Antiquities - Smith, 1890). Even after construction they had no significant economic impact since the cheaper forms of transport during that time were by river or sea (Finley, 1973). The military reason is also strongly supported from historical works and from the Latin literature. Chevallier (1976) emphasises the importance of the army's role in the case of the main roads. He remarks that *"the majority of main roads were pioneered by military operations. For example, on its return from the first Samnite war (343-40), the Roman army did not come back along the via Latina, but followed the coast through the territory of Aurunci, thus blazing the trail of the Appia on a line that had already been known to traders, at least since the hegemony of Etruria. In the early third century, operations against the Umbrians of Mevania and Narnia and against the Senones took into account the route that became the Flaminia. Great strategic road were built by the military in Gaul under Agrippa from BC 16-13 in Dalmatia and Pannonia under Tiberius from AD 6-9, in the Rhineland and the Danube valley under Claudius, and in Asia Minor under Flavians"*. Additionally, from a financial point of view, the road construction and reparation was a government responsibility. The officers who were in charge of raising funds for the roads were called ‘*curatores viarum*’: they could get money from private citizens interested in the use of the road, or donations from public figures. On the whole, the decision to construct and the founding were strongly centralized suggesting a modest impact at the regional level. The engineering mark of the Roman network is the second mainstay against reverse causality. The best-known feature of

Roman roads was their straightness. On this point Chevallier (1976) points out how *"As a rule, earlier sites were avoided by Roman roads, especially the great Imperial highways, which were unconcerned with local interests and small settlements... The road often attracted the village, but when the ancient road itineraries name a civitas, it does not mean that the route went through the town itself: occasionally it simply skirts its territory".* Dalgaard et al. (2015) clarify the absence of reverse causality through a very distinct figure which embraces both military and engineering subjects and showing how the typical Roman choice of roads construction was exogenous to development (see Figure 1).

When taking into account the progression of the road network project, it must be considered that the development of land transportation was more related to the cultural change from a society based on the city state, as it was the ancient Greece, to a state that was not a 'nation' but associated with a dispersed citizenship, like the Roman empire. During the Roman domination, Italy can be seen as a mixture of peoples across space, rather than a specific territory with one specific community. This led to a change in the mentalité of space and time, revolutionizing the importance in considering the territory and the time (Laurence, 1999). Although moving around was expensive and before leaving on a journey people were superstitious, the Romans enjoyed travelling for business and for amusement because mobility was a keynote of the society (Chevellier, 1976). The fundamental idea behind this paper lies on the concept of openness and connectedness: history, the ancient Roman civilization, could have had a positive long-term effect in terms of more propensity to trade with foreign peoples and this effect could have lasted for two thousand years. The positive impact of the Roman empire, in the view of this paper, is more 'cultural' than 'physical' (i.e. modern roads built on ancient Roman roads). Economists argue that, although the transport costs of that time, trade across the extended Roman empire during the first two centuries AD was possible; and it was possible thanks to a unified political system that could effectively enforces rules. In other words, it is not the transport cost but the cost of transacting that are the key obstacles that prevent economies and societies from realizing well-being (North, 1989).

Our focus on Italy is aimed at the cause of identification. Roman Italy was constituted to create unity. Laurence (1999) depicts Italy as a whole composed by a series of cities connected by the road system. In this perspective, the road network is a structure between places, which connects them to create an artificial unity and sums up the fluidity of the regions of the Italian peninsula under Rome. According to this, Italy represents an ideal case study for two main reasons. First of all, the Roman domination has touched the whole Italian territory shaping in a very strong and deep way its economy, society and space. The second reason can be found in the dual nature of Italy: a high-developed North-Centre and a less-developed South. Both traits are crucial in understanding whether and how much the concentrated existence of ancient Roman routes have affected trade costs today and therefore a stronger propensity to export and import abroad. From this perspective Italy perfectly applies in examining how different past local institutions, like the Roman roads project, determine current outcomes with a persistent effect.

The selection of Italian provincial level data is not trivial. The use of NUTS3 provinces allows us, on the one hand, to deal with a possible endogeneity problem between economic outcomes and historical transportation infrastructure, since it enables to gain more degrees of freedom from the local variability. On the other hand, as highlighted by Di Liberto and Sideri (2015), the provincial level in Italy represents a good geographical disaggregation to measure differences across provinces. Despite the central government has the main influence in determining institutions, the same institution seems to work differently, suggesting that some specific local factors affect the institution functioning.

On the one hand the empirical strategy is based on a model that captures the variability among the Roman road intensity measure (constructed using only certain and major roads) to explain differences within provincial trade costs. To assess geographical, weather and historical differences across provinces, time-invariant variables are included. Fixed effects to control for unobservable and specific regional characteristics complete the model. On the other hand, we use the old Roman roads infrastructure as an instrument for the current road infrastructure to evaluate whether provinces with a more intricate road network are more prone to trade internationally than internally since the influence of the Roman road system on the current one. Here the potential endogeneity problem from the use of the measure of current roads is avoided by the use of the Roman road measure (for which, as discussed above, reverse causality issues are less likely to be the case).

Overall results confirm previous findings in the literature. The existence of Roman roads has a negative impact on trade costs: provinces with a greater presence of Roman roads (more kilometres) have lower trade costs, meaning that they are more inclined to trade overseas than with themselves, according with the indirect measure of trade costs used. These results are robust when considering all Roman roads, only certain or only major roads, when Roman road measure is binary rather than in kilometres, when looking at the EU15 rather than at the world market and when using for our trade costs indirect measure a higher elasticity of substitution (σ=11). This work provides preliminary insight on the mechanics at work after the construction of roads at the time of Romans. Further developments associated with an higher propensity to trade abroad for those provinces with a denser road network need to be at the heart of further research along this line.

This paper is based on seven sections. Section 2 debates about the persistent effect of history giving account of a new stream of literature that deals with the link between historical factors and present-day economic outcomes, referring to those channels (institutions, infrastructures, geography) through which history exhibits its impact over the centuries. Section 3 gives an account of the constitution of a widely road network, considering the main features related to the development of the road network project and focusing on the state of mind behind the creation of a interconnected, efficient and cohesive empire. Section 4 presents a comprehensive exam of the measurement of trade costs and an extensive analysis of the top-down approach. Section 5 explains the data and how Roman roads have been measured at the provincial level. A twofold descriptive analysis on Roman roads and Italian Provincial trade costs is also provided. The empirical strategy and the related results are described in section 6. Section 7 concludes.

2. History, institutions, geography and infrastructures: the persistent effect

Historians and economists have argued how historical events influence economic development and how they have been crucial for better institutions and government attitudes. History matters in terms of persistence, and its long-term effect has been recognized for having important implications on actual economic patterns.

Starting from the work of North (1981), history has been found as having an important role in determining the current economic development, but it was during the first two thousands' decade that several contributions gave new insights on historical variables as fundamental determinants of growth and current economic outcomes.

A complete and structured review of the literature on the importance of the impact of history has been provided by Nunn (2009). Nunn distinguishes between an early period, corresponding with the late nineties - first years of two thousands, where three branches of research (each one composed by two works) can be considered as 'seminal contributions', and a subsequent phase, which corresponds with the first decade of two thousands, during which more sophisticated analyses, using finer data and advanced identification techniques, were developed. The six 'seminal contributions' of the early period are represented by the works of Engerman & Sokoloff (1997, 2002), Acemoglu et al. (2001, 2002) and La Porta et al. (1997, 1998).

De Benedictis and Pinna (2015) underline how the literature has followed two different strands. The first one relates to the new identification strategies of causal effects of history, the second one addresses the quantification of historical episodes, the digitalization of historical archives, the collection and compilation of new datasets based on historical data.

There are several channels through which history exhibits its persistent effect, but, as highlighted by Tabellini (2010), there is a widespread consensus for the legacy of history. Economists argue that it is through institutions that history shapes the current economic performance. Consequently, rather than giving a simple chronologically summary of the major contributions in the literature, the main purpose of this section is to understand why historical institutions are so important for quality and proper functioning of current institutions and why institutions, infrastructures and geography, through history, have a consistent long-run impact on the present development.

To identify in which way historical institutions carry out their effects on current economic performance, it is fundamental to have clear in mind what an institution is. Knight (1992) defines institutions as '*a set of rules that structure social interactions in particular ways*'. Similarly, for Hodgson (2006) institutions are '*systems of established and prevalent social rules that structure social interactions*'. In his view, '*language, money, law, systems of weights and measures, table manners, and firms (and other organizations) are all institutions*'.

As mentioned above, North(1989) stresses the importance of the costs of transacting for the performance of the economies and for the disparities between rich and poor countries. Theoretically, in society without formal contracting and with few formal specific rules, like personal exchange individuals society, costs of transacting are low because all those traits typical of industrial organization theory, like cheating, elusion, opportunism, are limited or absent. On the contrary, society in which the exchange of goods and services or the performance of agents is characterized by many valued attributes, like an impersonal exchange society, costs of transacting are high, because, on the one hand, there are problems in measuring what is exchanged, and, on the other hand, there is the need to enforce the terms of exchange. In order to minimize these costs and to reduce uncertainty associated with not or low regulated economic structures, institutional constructions need to be designed. Rich-Western countries, where specialization and division of labor are significant, necessitate complex but also more simple institutions, like formal contracts, guarantees, monitoring systems and enforcement mechanisms, to reduce costs of transacting, enable complex relationships and reduce uncertainty. In less developed countries, where costs of transacting are modest, institutions are less developed. In other words, institutions are formed when it is efficient to create them, i.e. when the social benefits of creating institutions exceed the costs of transacting.

The institutions, beneficial for the economic development, are principally represented by limited government, uncorrupt bureaucracy, legal system, low taxation and regulation. Economists came along with this conclusion centuries ago: Montesquieu and Smith, in the second half of eighteenth century, stressed the non-intervention of the Government, limited taxation and regulation as the best recipe for performance (La Porta et al., 1999).

The understanding of the persistence of institutions goes through the colonization history of the New World. During the sixteenth, seventeenth, and eighteenth centuries, Europeans settled their colonies in North and South America, but, how reported by Engerman and Sokoloff (2000), historians highlighted how colonizers were more interested in the potential opportunities of Caribbean and Latin America regions rather than in the less attracting northern territories. Although the Centre and South America were the favorite destinations of European settlers, economists wonder how the development of the U.S and Canada, rather than that of Southern American countries, has been possible. The economic leading position of the U.S. and Canada emerged just in the eighteenth century, two centuries after the arrival of the colonists. It was just during the industrialization that the divergence between North and South America emerged. In the seventeenth century historical data on per capita income suggest an homogeneity between those territories that were to become British colonies (the U.S., Canada) and southern regions. Economists and historians have tried to explain this different development between northern and southern countries, and all of them came across the same response: institutions. They highlighted that countries' growth is promoted by the security of property rights, absence of corruption, structures of the financial sector, social capital, investment in public infrastructure, and the propensity to work hard or be entrepreneurial. But, finding in institutions the fundamental reason for the different growth process across nations was not satisfactory, economists addressed more in depth the issue trying to explain where the differences in institutions come from. Although, they agreed in the "institutions-explanation", the origins they found out about where the differences in institutions came from were very dissimilar. North (1988) attributed the higher development of the U.S. and Canada to the fact that they were under the British domination, rather than under the Spanish or French control. Others were skeptical of such conclusion and explored different possible explanations more related to the factor endowments or initial conditions of territories. Engerman and Sokoloff (2002) suggested that the source of inequality based on differences in the initial factor endowments of the respective colonies. Indeed, the issue based on the influence of factor endowments to explain different growth path has long been stressed by the economic literature, what is new is the specific focus on how dissimilar are the environments in which the colonists settled their colonies. Differences in factor endowments are considered to be responsible for differences in development through their persistent impact on institutions, leading to inequalities in wealth, human capital and political power. Some authors, like Dunn (1972), Sheridan (1974), Moreno Fraginals (1976), Schwartz (1985), Knight (1990) pointed how the pervasive use of slaves in the production of sugar, coffee and other crops lead to big differences in wealth and human capital. Human capital improvements are also stressed in a recent work of Valencia Caicedo (2014). Combining information from historical archives and municipal census data, he finds out how Jesuit Missions in South America between 1609 and 1767 lead to current higher income levels underlying human capital as the main channel of transmission.

Alternative to institutions, geography has been recognized by economists as, not only, a fundamental determinant of economic development, but also as having long-run effects on it. Recently, there has been a large debate whether geography has a direct persistent impact on growth or not. Bleaney and Dimico (2014) refer to a separation between 'pro-geography' and 'pro-institutions' economists. Authors like Knack and Keefer (1995) and Hall and Jones (1999) stressed the importance of institutions on affecting growth in a persistent way, meaning that geography affects growth indirectly only through institutions; others, like Diamond (1997), Olsson and Hibbs (2005), Sachs (2003) found in geography a key and direct explanation for having long-run effects on economy. The well-known work of Acemoglu et al. (2001) emphasizes that only institutions matter for long-run economic growth, and that, once institutions are controlled for, geography has no significant direct effect on income. On the other hand, Sachs (2003) finds that geographical variables have a direct power in explaining the persistency in economic development.

Nunn (2009) refers to the debate in a more broad way distinguishing between 'pro-geography' and 'pro-history' economists. According to Nunn, the motivation behind the divergence lies in the fact that geography '*affects human actions in the past as well as today. In other words, in addition to affecting income directly, geography also influences history, which in turn affects current income*'. Contributions on this subject suggest that geography affects current economic mainly indirectly, through its influence on past events, rather than its direct effect on current economic outcomes.

Limao and Venables (2001) place their work between infrastructures and geography. They show the importance of infrastructures in determining transport costs and, consequently, bilateral trade, highlighting that remoteness, isolated and landlocked countries face higher disadvantages than coastal or island countries. A poor infrastructure system accounts 40% of predicted transports costs for coastal nations, 60% when considering landlocked countries. The key role of infrastructure for trade is strongly underlined by the work of Anderson and van Wincoop (2004). They highlight how poor infrastructures affect negatively trade and time costs. Their impact on trade costs influence in turn international trade volumes and this impact differentiate across countries. Banerjee et al. (2012) emphasize that transportation infrastructures are considered one of the main determinant of growth and development. The reason for this is twofold. First, because to benefit from markets and from ideas it is necessary to reach them; second, because historical construction of infrastructure such as railroads coincided with periods of rapid economic growth in Western Europe, Japan and the United States. Aschauer (1990) describes the importance of infrastructures for the quality of life and for the economic performance, highlighting that numerous past infrastructure investments have been responsible for significant improvements in the overall quality of life in terms of health, safety, economic opportunity, and leisure time and activities. Similarly, recent empirical evidence suggests that infrastructure expenditures may well have been a key ingredient to the robust performance of the economy in the "golden age" of the 1950s and 1960s. Volpe Martincus et al. (2014), in particular, stress the importance of policies aimed to invest in public domestic transport infrastructure in order to promote firms' exports and employment.

3. The Roman road network

The Roman empire has represented, in Italian and non-Italian history, one of the (say the) greatest empire of all time in terms of territory possessed and duration of political power. As highlighted by Laurence (1999), historians have recognized that the Roman state was involved in the development of an extensive transport network of roads from the fourth century BC, but have not managed to understand the impact of road building.

The tactical purpose, the logistic for the war campaigns and the supply of the army across roads represent the spirit of the road system and of the whole Roman empire. Although the military aim is at the core of the road network, when talking about Roman roads there are other four main aspects that should be considered and that are strictly related with the constitution of an intricate road system: i) the development of a great empire, ii) the advanced engineering abilities of the Romans, iii) the openness and mobility culture, iv) the other ways of transport and trade. In the present section we will briefly cover all five themes (military, empire, engineering, openness, transport) focusing on how the army purposes lead the engineering knowledge of Romans to construct roads that lasted till today, that served the foundation of a complex and huge empire continually expanding and that enabled openness and connectedness.

Starting from the military theme, Roth (1999) underlines that the Romans built their primarily for military reasons; the commercial travel was only a indirect beneficiary of the road network. The majority of the weight of the supplies of the Roman army was represented by three elements: food, fodder and firewood. Hence, all military decisions were determined by the need to assure the provision of supplies to the army. Accordingly, Thompson (1997) explains that the construction of a road network originated from the need to ensure that large number of horses, cattle's, carts and infantry were able to circulate: primordial non-Roman routes were problematic during wet and rainy days since the deep mud impeded or delayed the movement of goods and services. Therefore, the construction of a network of paved roads empowered not only the transport of goods and services enabling the movement of larger quantities and people and making transfers easier, but armies were able to travel twenty-five miles a day, even in bad weather conditions. During the Republican and Imperial periods, the Roman empire conquered territories in the Mediterranean Sea (like Sicily, Sardinia, Corsica, the northern coasts of Africa), in the Atlantic Ocean or in the Back Sea. Roth (1999) describes that the Romans were aware that moving supplies to the army by ship was cheaper and faster than by land, but transport by sea was dangerous and expensive. Seafaring in the Mediterranean was limited between March and November, although it was really safe only during the summer months (from June to September). On the contrary, land transport had no limitations and it was practicable during all over the year. The Romans understood that the need of a logistical infrastructure was fundamental for the movement of armies and supplies and consequently for the enlargement of the empire. Hence, in order to facilitate the move of the army to place to place, they constructed roads intended mainly for wagon travel used for the supplies; soldiers and pack-animals could travel as well. Since the military purpose was the priority for the Romans, therefore expansion, maintenance and repairing of the road network were continuously performed and associated with military campaigns and for strategic and tactical purposes.

Historians have argued how the design of an intricate road system and the development of a great empire were strongly correlated. On this point, Thompson (1997) argues that the vast and comprehensive Roman road system changed the entire empire. Accordingly, Gleason (2013) stresses that the enlargement of the empire was possible thanks to a developed road system. In fact, the Roman army was too small to conquer the enemies of Rome, but the constitution of a vast empire was possible investing in the construction of a complex road network rather than enlarging the infantry forces. Knapton (1996) underlines that the new conquered regions on the one hand enlarged the Roman empire contributing to their power, authority and wealth; on the other hand the payments of conquered territories were mainly used for the public infrastructures, like roads and aqueducts. This led to the development of the engineering capability of the Romans. The peak of the Roman empire corresponds with full extent of the road network (117 AD - death of Trajan) as further proof of the fact that roads construction and the constitution of a vast empire were highly related.

The engineering behind the construction of roads subtend incredible and high-level skills. Romans were mainly focused on getting the road straight since it was easier for the network structure and shape. To achieve this straight configuration, they define point that could be quickly connected by a straight line (Davies, 1998). Accordingly, Gleason (2013) explains that to mark the road's path with either stakes or furrows creating roads as straight as possible, was the first purpose of Romans. Legionaries and slaves belonging to the army were involved in the roads construction process. This process included first of all the digging of a 1.5 meters deep trench for the width of the road. In order to guarantee the stability and durability of the substrate, the trench was being filled and packed with several texture and type of material from the land around it. Then they applied a layer of gravel or pavestones ensuring that the road had a camber, or rise in the centre, to prevent erosion and make the surface all-weather capable.

Behind the development of an intricate and technological road system there is a culture of openness and mobility. Geographical distance between places creates distance between people. Knapton (1996) describes how the Roman road network represented a system which connected different peoples and cultures from Newcastle to North Africa, from Portugal to Arabia. The Italian territory was itself a mixture of peoples: Greek colonies and the Samnites in the south, the Latins and the Sabines in the centre, the Etruscans in the north of Rome, the Celts in northern Italy and other peoples in the rest of the peninsula. During what has been called 'the golden age of Roman road building' (second century BC), the Roman empire became interlinked with a network of roads which led to greater mobility and the Romans used to live overseas and to become wealthy. On this point, Laurence (1999) highlights that the understanding of the nature of Roman space-time is fundamental to appreciate the cultural change associated with road building and the improvement in terms of road technology. Roman roads changed the speed of communication and created connections throughout the year: the space-time concept integrated the elements of physical distance and time taken to complete a journey over that distance. The road system created an interconnection between places that allowed for a mobile elite and citizen body and also the mobility of surplus products and profits. The developments in technology to the road system and the increased efficiency of transports, together with a mentalité of space-time that emphasised the transport of people and goods over a distance, were features of a culture that had an emphasis on mobility. The issue of mobility was embedded particularly in a system of elite land holding that depended on mobility of the landowner for its economic survival and an elite culture that laid claim to active involvement in the management of their estates (Laurence, 1999).

Road transport can be seen as a complementary system of river and maritime transport. It has been argued that land transport was an inferior, expensive alternative to maritime transport. Goods were continually transported throughout the Roman Empire and it has been largely discussed that, despite the risks, dangers and problems, the most effective way to transport goods was by sea. Depending on its size, it could carry cargo weighing between 70 and 350 ton (Snedden 1998). Ships were preferred to roads since they could transport large amount of goods and people in a shorter time. Six hundred passengers or six thousands amphorae of wine, oil and other products were highly traded using sea transports. The Romans put much effort in improving the effectiveness of shipping, developing harbours and lighthouses. The journey from Egypt to Rome took only two to three weeks by ship. When transporting commercial goods, river transport was also used e preferred to roads, and the same principle applied for the movement of military supplies. The access to the inland regions of the empire was allowed by the large navigable rivers: the Rhône into Gaul, the Rhine into Germany, the Danube into Pannonia, Dacia and Noricum, the Tigris and the Euphrates into Mesopotamia and the Nile into Ethiopia (Roth, 1999). Despite the apparently overwhelming economic advantage of trade by water, Pawson (1977) pointed to the key advantages of land transport arguing that, the land transport system could be classified in two parts: a complementary system, which was interdependent with water transport and performed a feeder and distribution role for it, and a competitive, independent system which did not rely on water transport linkages.

4. Trade costs: the top-down approach

In an increasingly globalised and networked world, trade costs are an important determinant of the pattern of bilateral trade and investment, as well as of the geographical distribution of production. From a policy perspective, they are of great importance in determining a country's ability to take part in regional and global production networks.

Trade costs are all those costs of getting a good to the final consumer other than the cost of producing the good itself. They include measurable elements and not: distance, transportation costs (both freight costs and time costs), policy barriers (tariffs and non-tariff barriers), internal trade and transaction costs (including domestic information costs, contract enforcement costs, legal and regulatory costs, local distribution, customs clearance procedures, administrative red tape, etc.), the lack of a common border, history, language, currency, to not participate in the same economic community.

Technology and communication have shortened distance and have enabled trade of goods and services in a faster and easier way as it was in the past, the potential trade flows between countries are lower as they could be. The reason must be found on trade costs: although trade costs experienced a reduction over the last thirty years, they are high and impede complete integration between nations.

Novy (2013) highlights that the decline in international trade costs, first of all the reduction of transport costs and tariffs, as the main cause of international trade increase in the last three decades. Anderson and Van Wincoop (2004) state that trade costs matter and are large, although tariffs in many countries are now at historical lows. The tax equivalent of trade costs for developed countries is estimated to be equals to 170 percent: 21 per cent transportation costs (including both directly measured freight costs and a 9 per cent tax equivalent of the time value of goods in transit), 44 per cent border-related trade barriers and 55 per cent retail and wholesale distribution costs. Hoekman and Nicita (2011) show that non-tariff measures and domestic trade costs represent relevant barrier to international trade. The decline and the increase of total trade costs weigh on trade booms and trade busts during the globalization eras. Jacks, Meissner and Novy (2011) find that the decrease of trade costs during the first globalization era (1870-1913) were responsible for 60% increase of international trade flows; during the second era (1950-2000), the decline in total trade costs accounted for more than 30%. The pre-World War I trade boom can be explained by a decline of 55% in total trade costs, 33% when considering the post-World War II trade boom; a steep rise in trade costs explains the entire interwar trade (Jacks, Meissner and Novy, 2008). Rubin and Tal (2008) argue that transportation costs represent a greater barrier to trade than policy-induced obstacles, such as tariffs. Obstfeld and Rogoff (2000) claim that trade costs are the explanation to the "six major puzzles" in modern international macroeconomics. A detailed knowledge of trade costs across the entire trade chain is the main purpose of Moïsé and Le Bris' (2013) contribution. Considering that to understand trade costs in a complete manner is fundamental to plan policies to reduce trade costs, they provide a comprehensive report with a conceptual framework for policymaking.

Despite their importance as drivers of the geographical pattern of economic activity around the world, research on trade costs remains limited. Nevertheless, there have been many attempts to develop trade cost measures. Much effort has focused on direct measurement of various trade cost components, such as international transport costs (using actual shipping costs of a standard container to various destinations or more aggregate 'cost, insurance and freight' (CIF) and 'free on board' (FOB) trade data), or costs of moving goods from the factory to the deck of a ship at the nearest sea port (including cost of preparing trade documentation, customs clearance, goods transport and handling to the port). In particular, literature on trade costs has focused on demonstrating that a specific factor(s) has a significant impact on bilateral trade flows as captured through the standard gravity model of international trade. By summing the parts together, this 'bottom-up' approach can produce an estimate of the overall level of trade costs facing exporters and importers. However, these approaches do not provide a comprehensive measure of international trade costs – and combining the different measures and indicators into a comprehensive measure is hardly feasible. In addition, data coverage is often limited to a few countries, industries, products or years (Anderson and van Wincoop, 2004). To date, only Anderson and Van Wincoop (2004) have undertaken such a summing exercise, and their total, 170 per cent ad valorem, is of major economic significance.

More recently, another strand of research has turned the gravity model on its head to obtain ‘top-down’ estimates of trade costs, by inferring them from the observed pattern of production and trade across countries (Novy, 2013). The earliest indirect approach to measure trade costs has been developed by Head and Ries (2001) which propose an inverse measure of the ‘phi-ness of trade’. To construct this measure they assume that the intra-national trade is costless, whereas the inter-national trade has symmetric trade costs. Head and Ries (2001) consider two alternative trade models to show how the effect of trade costs changes according with different specialization and market size features. Starting from the Head and Ries' (2001) work, Novy (2013) extends their approach demonstrating that the indirect measure of trade costs originate from different theoretical trade model. In his work he rests on three main model: the gravity model by Anderson and van Wincoop (2003), the Ricardian model by Eaton and Kortum (2002) and the heterogeneous firms models by Chaney (2008) and Melitz and Ottaviano (2008).

The indirect approach tries to infer implied trade costs from trade data without specifying a trade cost function. The idea is that if a country-pair satisfies the internal demand of both countries in a small amount through trade with respect to internal production, then the inference is that trade costs should be quite high. To produce a comprehensive aggregate measure of bilateral trade costs the World Bank recently produced a sectoral measure of the same class of indices used in this analysis, using the Inverse Gravity Framework methodology (Novy, 2013). The measure is truly comprehensive in that it includes all costs involved in trading goods internationally with another partner (i.e. bilaterally) relative to those involved in trading goods domestically (i.e. intra-nationally). It captures trade costs in the wider sense, including not only international transport costs and tariffs but also other components of trade costs, such as direct and indirect costs associated with differences in languages, currencies, as well as cumbersome import or export procedures (Anderson and van Wincoop, 2004).

According to Novy (2013), bilateral comprehensive trade cost is defined as follows:

$$\tau_{ij} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1$$

where:

- τ_{ij} represents geometric average trade costs between country i and country j
- t_{ij} represents international trade costs from country i to country j
- t_{ji} represents international trade costs from country j to country i
- t_{ii} represents intra-national trade costs of country i

- t_{jj} represents intra-national trade costs of country j
- x_{ij} represents exports from country i to country j
- x_{ji} represents exports from country j to country i
- x_{ii} represents intra-national trade of country i calculated as GDP minus total exports[1]
- x_{jj} represents intra-national trade of country j calculated as GDP minus total exports[2]
- σ represents the elasticity of substitution across goods, where σ>1.

The final measure τ_{ij} represents the geometric average of international trade costs between country i and country j relative to domestic trade costs within each trade partner. According to the measure, when the ratio raises trade costs are higher and countries are more likely to trade domestically than internationally. On the contrary, as the ratio falls , trade costs are lower and countries tend to trade more with their trading partners than they do with themselves. In other words, data of the relative openness of a country can be interpreted as the extent of its trade costs: if the country ships abroad that part of its production that was previously consumed domestically, it means that the country is more opened and its trade costs are lower. Because trade costs are derived from a ratio with trade flows in the denominator, country pairs that do not trade at all record infinite trade costs. Moreover, the measure allows for asymmetric bilateral trade costs (tij ≠ tji) and for unbalanced trade flows (xij ≠ xji) between the pair. It includes all factors that contribute to the standard definition of iceberg trade costs in trade models, namely anything that drives a wedge between the producer price in the exporting country and the consumer price in the importing country. Therefore, trade costs, as defined here, include both observable and unobservable factors. (Arvis et al., 2013).

The value of the elasticity of substitution affects the indirect measure of trade costs, however the literature suggest that results are not sensitive to used parameter. Novy (2013) assumes that the elasticity is constant across sectors, countries, and years and set an elasticity of substitution equal to 8.

The way according to which the indirect measure of trade costs is constructed involves both advantages and pitfalls. The first strength lies in the ease of the empirical implementation with country level and long series available data, making it extensively useful in studies with numerous countries and long term period. The second advantage of Novy's approach is the 'all inclusive' character of the measure, comprehensive of all those components of trade costs that are difficult to observe or to measure using a direct method. Third, differently from each gravity approach, where a function is needed to rely on some geographical explanatory variables (such as distance), the

[1] x_{ii} may also be named 'internal trade' of country i.
[2] x_{jj} may also be named 'internal trade' of country j.

indirect measure infer trade costs from observable data not requiring the use of a trade cost function. The fourth strength is the absence of a possible problem of omitted variables or endogeneity bias: since it is a theory-based measure and not an econometric estimation there is no chance to omit important variables from the measurement or to run into simultaneity.

This measure is also plagued by some drawback. First, since the measure is the geometric average of trade costs in both directions, from a policy perspective, it is therefore impossible to say without further analysis whether a change in trade costs between a country pair is due to actions taken by one government or the other, or both. Single sub-components represent just a fraction of overall trade costs, therefore trade cost measured in this way need to be interpreted as an all-inclusive estimate, while recognizing that only part of the total will be amenable to direct policy action by governments. Second, the interpretation of τ_{ij} depends on the theoretical model from which it is derived. A third pitfalls lay in the precision of the indirect approach: due the construction using not true components of trade costs, the accuracy of the measure may be debated.

5. Data

In this section we describe firstly data used for the empirical analysis, accounting for sources and calculations. Secondly, some descriptive analysis are provided to understand data attitudes.

Geo-coded data on the Roman road network refers to the McCormick et al. (2013) shapefile, a linear layer obtained digitizing the information in the "Barrington Atlas of the Greek and Roman World (2000)".

The shapefile includes 7154 segments of ancient Roman roads existing at the peak of the empire, corresponding with the death of Trajan (117 CE). Roads are classified if major or minor and if certain and uncertain roads.

Starting from a polygonal shapefile of 110 Italian provinces (Source: Istat, 2011) and using Quantum GIS, the challenge of this work was to construct a single measure of Roman road by Province. On this aim, we superimposed the linear Roman roads layer on the polygonal one and we constructed a measure of kilometres of Roman road by Province in order to capture the incidence of the Roman infrastructure. We computed five different measures: i) kilometres of all Roman roads; ii) kilometres of just certain Roman roads; iii) kilometres of just major Roman roads; iv) kilometres of major and certain Roman roads; v) binary variable: 1 if the Province has Roman roads.

To measure trade costs we adopted the 'top-down' approach proposed by Novy (2013) calculating a simple average of the bilateral trade costs between provinces and countries, obtaining a single measure for each Province and each year. Accordingly to the 'top-down' approach, to compute trade costs we needed four main elements: exports from Province i to country j, exports from country j to Province i, intra-provincial trade of Province i calculated as GDP minus total exports, intra-national trade of country j as GDP minus total exports. Data on imports and exports at a provincial level refers to 192 countries in the world from 2003 to 2010 (Source: Istat). To calculate internal trade by Province we used the value added (VA) to decompose GDP for Italy from World Bank at the province level and we then subtracted the total value of exports, computed summing up provincial exports. Intra-national trade was computed using GDP reported in the World Bank WDI dataset and subtracting the total value of exports obtained using bilateral trade data from the Cepii revision of the Comtrade UN database. To preserve the information inferred when trade is absent we replaced the value of zero trade (no trade) with one, which allows us to preserve observations that are important for the aim of our analysis.

To complete the analysis we used data on geography, weather and history in order to control for those characteristics that typically distinguish Italian provinces from each other. Given the Italian provincial data availability and according to the Acemoglu et al. (2001), where the large effects of institutions on income per capita are robust, among others, to climate, latitude, distance from coast, and similarly to Spolaore and Wacziarg (2013), where 44% of contemporary variation in log per capita depends on a small group of geographic factors (latitude, the percentage of a country's land area located in tropical climates, a landlocked country dummy, an island country dummy), we used those geographical and weather variables that enabled us to trace the direct access to the sea, the average temperature and the elevation of territory (Source: Istat).

Historical factors are identified for each Province through two different sets of measures from Di Liberto and Sideri (2015). Both groups categorize the foreign dominations that ruled in Italy in the past centuries. The first set of variables is represented by a series of dummy variables that identify, for each province, the administration that occurred from the middle of the sixteenth century to the middle of the seventeenth century, namely, the period from 1560 to 1659. During this century the Italian peninsula was governed by five different formal governments together with a significant part of the (northern) Italian peninsula which maintained a certain degree of independence. Consequently, six binary variables have been defined: the Spanish Kingdom, the Republic of Venice, the Duchy of Savoy, the Papal State, the Austrians, the independent area. The second set of variables refers to all different regimes that governed each Italian Province over seven centuries before the creation of the unified Italian State, namely, the period from about 1100 to 1800, assigning to each province the number of years during which each regime has persisted. During these 700 years nine dominations occurred: the Normans, the Swabians, the Anjou, the Spanish, the Bourbons, the Papal State, the Savoy, the Austrians and the Republic of Venice. Di Liberto and

Sideri (2015) find that if a province has been dominated by the Papal State, the Spanish rule or the Normans it has had a negative impact on institutional quality; results on the other dominations are less clear-cut. According with historian portrays, it is possible to expect negative or positive effects from each domination. Historians usually depict Normans, which ruled in the southern areas and the independent towns in the North, as having negatively affected social capital levels and, through that, development. The Swabian is identified as a positive domination: they controlled the Kingdom of Sicily (including the whole Mezzogiorno) until 1266. From 1266 the Anjou conquered the Southern Italy, but their administration was judged negatively since the strong fiscal system, the regular fights against local feudal nobility, the strict military control, the continuous wars and the abolishment of the modern state constructed by Swabians during the previous century. The Spanish kingdom influenced Italy for a long time, but because of its inefficient institutions, bureaucracy and the implementation of extractive policies in foreign territories, the Spanish domination is depicted negatively by historians. The successors of the Spanish domination in South Italy (Mezzogiorno) were the Bourbons. Since the incapacity to improve administration in the territories inherited by the Spanish, the Bourbon domination cannot been judged has having had a positive effect on development. In the Centre of Italy, the Papal State ruled for the most part of the period examined. Although it gave evidence of good administration, it was limited on the city of Rome, in the other territories there was a diarchy between the religious and the local power. For these reasons the Papal state is expected to have had a negative influence on institutions. The Savoy governed in in the Aosta Valley, in Piedmont till in Sardinia. The effect on institution of the Savoy domination is ambiguous: although the government was characterized by a strong central power and an authoritarian bureaucracy, the Savoy constituted a modern organization with the gradual passage from a feudal state to a modern one, but only in the Northern territories. The Austrian domination, which dominated Italy since 1713, is considered as having positively affected institutions. They ruled before in the North-East of Italy, then they conquered the Duchy of Milan, Sardinia (until 1720), the Kingdom of Naples and Sicily until 1734. They influenced also Tuscany and the Duchy of Parma and Piacenza. The Republic of Venezia has been the only state to preserve a full independence. Because of the political stability and the economic prosperity it should have had a positive impact on the institutional organization (Di Liberto and Sideri, 2015).

The persistence of the Roman road infrastructure on the current one is assessed considering the length in kilometres of all current roads by Province. We use data from Automobile Club d'Italia (ACI) updated to 2011. Until 2011 there was a lack of data regarding the provision of road infrastructure in the different and comprehensive territorial levels. ACI filled up the need of more detailed data collecting information from different sources. Data on motorways come from

AISCAT and from ANAS. ANAS provided also data on national interest roads. The regional roads have been identified first according to the Decree of the President of the Council of Ministers (DPCM) 21/02/2000, in accordance with the Legislative Decree (LD) n. 112 of 1998, singling out the roads not included in the highway and in the national road network and, then, thank the collaboration of ANAS and the Regions and Provinces or through published material. For provincial roads AIC used first the published catalogues when available; in the remaining cases it was conducted a survey among the provinces themselves. Only in a few cases it has not been able to find the necessary information. ACI classifies by Province five different typologies of roads: motorways, regional roads, provincial roads, roads of national interest, roads 'to be classified'. The sum of all of these roads gives the total extension of roads by Province. Since not all types of roads are included in each province (there are provinces without motorways) we consider as our measure of current roads length the sum of all roads. Appendix A (Table A2) lists and ranks provinces according to the length of total roads they include.

We proved a dual descriptive analysis giving account of the main independent variable (the Roman roads measure) and of the dependent variable (the indirect measure of trade costs).

To provide a general picture about the density of the Roman road network, density across provinces is fundamental to appreciate its extension and ramification. As previously reported, the data set is composed by 7154 parts of Roman roads (Figure 2); 2177 when considering just Italy. These segments are not single roads, but they compose a road. For each part of road we know if it is a certain or uncertain road and if it is a major or minor road. 108 out of 110 Italian provinces have Roman roads, 94 have major roads, 85 have certain roads. When considering certain and major Roman roads together, we count 77 provinces.

Figure 3 shows the distribution of Roman roads in the Italian peninsula. When considering all the roads (certain and uncertain, major and minor), it seems that the Romans devoted more efforts on building roads in the South rather than in the North. A possible explanation of this fact can be found in the way the Roman empire enlarged: firstly towards the southern regions, then to the north. When looking just to the certain or to certain and major roads together, this weak spatial distribution disappears. Appendix A (Table A1) lists and ranks provinces according to the length of Roman roads they include, emphasizing how considering just certain roads leads to changes of ranks: some provinces on the top when considering all Roman roads loose position when looking at certain roads.

Some historians disagree with this clear categorization of roads, arguing that some of those roads classified as uncertain in the data set of McCormick et al. (2013) are instead certain, since the recovery of Roman milestones in those territories, marked as areas crossed by Roman roads, is an unambiguous sign of the existence of the road. We took advantage from this puzzle, performing our empirical analysis using only certain roads, only major roads, both certain and major roads together and all roads included in the data set.

Our descriptive analysis on trade costs is twofold. On the one hand, differences between the world and the European (EU15) market need to be investigated in order to control for distance and advantages to trade with EU countries. On the other hand, the long-lasting duality between northern and southern Italy is examined to consider how large these dissimilarities are. The distribution of trade costs at the provincial level is provided in Figure 4. In order to appreciate differences across provinces, we computed trade costs using an elasticity of substitution equals to 8. We separated calculations for the global market from the EU15 market to verify whether there is a non-linear effect of trade costs and distance. Our calculations reveal that trade costs in the world market present a space distribution that is connected to the level of wealth. There is a discrepancy between the northern and the southern provinces, but trade costs are also higher in provinces near the Italian border, where connectivity is still influenced by geography (i.e. the area's mountainous terrain). Moreover Figure 4 highlights that this clear divergence between North and South is accentuated when considering the world rather than the EU15 market. It is interesting to notice how trade costs for the world market seem to be lower than those for the EU15 market. Trade costs for the world market vary from a minimum of 3.64 to a maximum of 22.91; for the EU15 market they are 1.19 and 30.09. But it must be considered that just one Province in Italy has for the EU15 market trade costs equal to 30.09; for the remaining 109 provinces trade costs are only up to 9.17. For the world market, instead, 8 provinces are included in the category 15.86-22.91 and more than 20 provinces have trade costs included between 11.56 and 15.86, revealing that trade costs for the world market are higher than for the EU15 market. Figures 5 shows the Kernel distribution of Italian provincial trade costs aggregated to the country level and calculated for the EU15 and for the world market using a bandwidth h = 0.1. The dash blue line, which represents the world market, shows clear twin peaks, confirming the remarks we made above. More on the duality between northern and southern Italy is examined in Table 1, where differences across Italy are analyzed looking at its four major socio-economic regions. Without surprise, provinces in the North-east and North-west areas of Italy are characterized by lower trade costs whether considering 2003 or 2010 (first and last years of the data set) and, regardless of the trade costs measure, we use (with σ=11, σ=8 or σ=7). Provinces in the centre are halfway between a developed North and a less-developed South. The backwardness of the southern provinces reflects in higher trade costs.

6. The empirical analysis

6.1. Roman roads and current trade costs

The first approach aims to assess which is the pure effect of the Roman road network on our current measure of indirect trade costs, focusing on the persistent and deep effect of history on present economic outcomes in a more comprehensive way.

The econometric methodology consists on estimating a model where the dependent variable is represented by the average of international trade costs by Province: one measure for each Italian Province for each year between 2003 and 2010. The main independent variable is represented by our measure of Roman roads. The other covariates are represented by a series of geographical, weather and historical variables and regional fixed effects in order to avoid collinearity problems.

$$\tau_{it} = \alpha_0 + \alpha_1 RR_i + \alpha_2 \boldsymbol{X}_i + \eta_s + \gamma_t + \varepsilon_{it}$$

where:

τ_{it} denotes our dependent variable, the average of all trade costs of each Province i and its countries partners j for each year between 2003 and 2010

RR_i denotes our measure of Roman roads by Province

$\mathbf{X}_i$ denotes a vector of geographical, weather and historical measures by Province

η_s denotes regional fixed effects

γ_t denotes time fixed effects

ε_{it} denotes the error term

We also perform estimates using cross-section rather than panel data, calculating the mean of our indirect measure of trade costs.

All the empirical analysis uses the same dependent variable, the logarithm of the geometric average of international trade costs (world market) with elasticity of substitution constant and equals to 8. According to Anderson and van Wincoop (2004) the elasticity of substitution used affects the value trade costs. They explain that three different ways have been used in literature to obtain an estimate of σ: one method comes from the observation of trade barriers; a second approach refers to demand equations; a third method is the approach proposed by Eaton and Kortum (2002). The first procedure to obtain σ refers to directly observed trade barriers, like tariffs and transport costs, and to estimate gravity equations using sectoral data for two or more countries. As suggested by Anderson and van Wincoop, the most relevant contribution on this approach are those of Hummels (2001), Head and Ries (2001), Baier and Bergstrand (2001) and Harrigan (1993). Hummels (2001), considering a tariff rate and freight factor and using data on sectoral imports of six countries from a large number of other nations, finds that the elasticity rises from 4.79 for one-digit SITC data to 8.26 for four-digit SITC data. Head and Ries (2001) consider only two countries, the United States and Canada, three-digit industry data and tariff and non-tariff barriers. They obtain an elasticity of substitution of 11.4, when non-tariff components don't vary across industries, and 7.9 when changes are allowed. Baier and Bergstrand (2001) referring to OECD countries and using only tariffs and transport costs as trade barriers, obtain 6.4 as an estimate of the elasticity of substitution. Harrigan (1993) estimates the effects of non-tariff barriers on the bilateral imports of ten large OECD countries from 13 trading partners in 1983 for 28 sectors obtaining different estimates of σ, that ranges from 5 to 10. The second method obtains estimates for σ from demand equations, using data on price. Anderson and van Wincoop indicate the contribution of Feenstra (1994) on this approach. In its work Feenstra uses the fact that variance and covariance of demand and supply changes have a linear relationship that depends on demand and supply elasticities. Using data on U.S. imports for six manufacturing sectors with more than eight-digit SITC, the estimates for the elasticity of substitution ranges from 3 to 8.4. Eaton and Kortum (2002) employing a specific equation to calculate σ, use data on retail price levels for fifty manufactured products in nineteen countries obtaining an estimate of 9.28. From these three different ways to compute the elasticity of substitution of trade costs, Anderson and van Wincoop conclude that σ is likely to range from 5 to 10 and they suggest that estimates for goods that are more differentiated and therefore less substitutable, are around 7 or 8. In their work, Duval and Utoktham (2011) use an elasticity of substitution equals to 8. According to Eaton and Kortum (2002), Jacks et al. (2010) and to Anderson and Yotov (2012) we check the robustness of our estimates also computing trade costs with elasticity equals to 11. Elasticity of substitution equals to 11 corresponds to a 10% markup over marginal cost.

Table 2 reports the main regression analysis, inclusive of eight specifications and where the Roman roads measure has been computed using only roads that were certain. The first four regressions refer to the panel data set (clustered standard errors at the provincial level have been computed), regression from 5 to 8 refer to cross-section data. First three regressions in each group refer to the Roman roads index in kilometres, the other ones consider the binary measure. In all specifications we use geographical, weather and historical controls and include regional fixed effects. Historical controls change across regressions, depending on whether we incorporate dominations as dummy variables or in years. Tables from 3 to 5 follow the same structure of Table 2, but to construct the Roman roads index we employ both certain and major roads (Table 3), all roads (Table 4) and only major roads (Table 5).

Significance and negative sign of the coefficient associated to the Roman roads index persists in almost all the specifications, independently on how the Roman roads measure has been computed, showing that lower trade costs are linked to a more intense road network.

We use a index of altitude to quantify topographic heterogeneity. The effect on trade costs of this measure is negative rather than positive. It seems that the more mountainous the territory is, the lower trade costs are. This index is low significant or even not significant in almost all specifications, stressing the fact that the elevation and the ruggedness of the territory have not, at the provincial level and for trade costs, a so large effect as the existence of Roman roads have.

The coastal dummy is mainly not significant. Having a direct access to the sea is the geographical condition which has been found to be the main advantage for the economy of a country: coastal countries are richer (Bloom and Williamson, 1997) and trade 30% more than landlocked countries (Limao and Venables, 2001). These kind of thoughts seem to not apply when considering data at the provincial level.

Significance and positive, rather than negative, effect on trade costs of past dominations seem depending on the specification and domination is taken into account.

Appendix B provides some robustness checks. In Table B1 we refer to EU15 market, while in Table B2 we employ as dependent variable the trade costs measure calculated using an elasticity of substitution equals to 11.

6.2. Roman roads, current roads and current trade costs

The second approach goes much more in-depth, assessing whether the old Roman infrastructure had a persistent effect on our current measure of trade costs via the current infrastructure. This second method is aimed at the channel through which Roman roads performed and is more linked to the indirect effect of the historical infrastructure.

According to Kessides (1993), current infrastructures affect economic development and performance in a large number of ways, acting through different channels and including externalities, spillover effects and indirect mechanisms that must be taken into account. In this framework, assuming that better economic outcomes are determined by denser current road network and not vice versa is a very strong assumption. As said above, literature highly supported the idea according to which roads and railways are often built to connect already developed regions, but regions can reach development after the construction or improvement of infrastructures. It is more likely that rich countries/regions/provinces can afford better infrastructures. In order to avoid the potential simultaneity problem connected with the use of a measure of current roads (CR), we use a two-stage least square (2SLS) approach on a panel data set, using our measure of Roman roads

(RR) as an instrument in the first stage. In the second stage the dependent variable is as usual represented by the average of all trade costs of each Province i and its countries partners j for each year between 2003 and 2010 (τ_{it}). The 2SLS estimator with only one instrumental variable is identical to the Instrumental Variables (IV) estimator.

First stage (one instrument):

$$CR_i = \delta_0 + \delta_1 RR_i + \delta_2 \boldsymbol{X}_i + \eta_s + v_i$$

Second stage:

$$\tau_{i\,t} = \alpha_0 + \alpha_1 \widehat{CR}_i + \alpha_2 \boldsymbol{X}_i + \eta_s + \gamma_t + \varepsilon_{it}$$

The advantage of the IV methods basically rest on addressing omitted variable bias, measurement error or reverse causality problems, that typically raise in Ordinary Least Square (OLS) regressions. On the other hand, to employ IV, two important conditions need to be fulfilled: Cov (CR, RR) ≠ 0 in first stage; Cov (RR,ε) = 0 in second stage. The first condition refers to the correlation between the old infrastructure and the current infrastructure and is easily verifiable through the first stage statistics. The key idea behind is that territories with a denser roman road infrastructure are more likely to have a denser present road infrastructure. The second condition requires that the instrument is uncorrelated with any other determinants of the dependent variable. While we can test whether the first condition is satisfied, the second condition cannot be tested because our model is exactly identified (number of instruments equal to the number of endogenous regressors). Over-identified models allows instrument exogeneity to be tested. In short, the challenge of employing instrumental variables methods is finding valid instruments; an instrument is valid when it is relevant (i.e. it fulfils the first condition) and exogenous (i.e.it fulfils the second condition). It is challenging to find variables that meet the definition of valid instruments: conceptually, most variables that have an effect on endogenous variables may also have a direct effect on the dependent variable.

Table 6 shows our IV estimator results. All six specifications refer to panel data: we use as dependent variable the trade costs measure referring to the world market with an elasticity of substitution equals to 8. In the first three regressions the variable being instrumented is the total length in kilometres of current roads. In the last three regressions we instrument kilometres of motorways. Instrumental variables change for each regression. For the total length of current roads we use certain Roman roads in the first specification, certain and major Roman roads in the second and all Roman roads in the third. For the length of current motorways we use certain Roman roads, certain and major Roman roads and major Roman roads. For each model we report also the first-stage estimates, namely the effect of the Roman roads measure on the current road variable.

The current road measure is highly significant and with the expected sign in all six models, regardless to the instrumental variable used and whether we use the total length of kilometres of roads or we consider just kilometres of motorways.

Geographical and weather variables are highly significant in each specification: like in the panel and cross-section estimations, elevation has a negative rather than a positive effect on trade costs. Differently, the coastal dummy seems to work quite well with the IV estimator. Provinces having a coast take advantage of this geographical condition: a direct access to the sea has a beneficial effect on trade costs, reducing them.

Since the strong assumptions needed to perform 2SLS, the IV analysis requires a set of tests to control for the issues that can occur using instrumental variables. Basically, heteroskedasticity, weak instruments, exogeneity and endogenous regressors are the four main problems that should be detected after a IV estimate. Testing for the failure of the exclusion restriction (exogeneity) is not possible with our exactly identified models.

According to Baum et al. (2002) an every-present problem in empirical work is the presence of heteroskedasticity. Although IV estimates are consistent and not affected by heteroskedasticity, the standard IV estimates of the standard errors are inconsistent, preventing valid inference. These problems can be addressed in part through the use of robust standard errors and statistics. Though consistent, the IV estimates are, however, inefficient in the presence of heteroskedasticity. Moreover, the usual forms of the diagnostic tests for endogeneity and overidentifying restrictions will also be invalid if heteroskedasticity is present. The test of Pagan and Hall (1983) has been designed specifically for detecting the presence of heteroskedasticity in IV estimation.

Table 6 shows the Pagan and Hall's test results. The null hypothesis of homoskedasticity is always rejected. In order to partially deal with heteroskadasticity, robust standard errors have been computed for each specification.

Testing for the failure of the relevance condition (weak instruments) is the second check inescapable with IV estimates. Basically the standard errors on IV estimates are likely to be larger than OLS estimates, and much larger if the excluded instrumental variables are only weakly correlated with the endogenous regressors (first condition not completely or not satisfied). We check for the problem of weak instruments using the “rule-of-thumb” diagnostic. Staiger and Stock (1997) formalized the definition of “weak instruments” and developed a test that rejects the null hypothesis of weak instruments if the F-statistics in the first stage is larger than 10. Table 6 reports the first-stage F-statistics for all models: the very high values are a proof of the validity of the relevance condition and for the absence of weak instruments.

Stock and Yogo (2005) go into more detail and formalise Staiger and Stock's procedure. They provide useful rules of thumb regarding the weakness of instruments, based on a statistic due to Cragg and Donald (1993), where the null hypothesis being tested is that the estimator is weakly identified in the sense that it is subject to bias that the investigator finds unacceptably large. The null hypothesis of weak instruments can either be defined in terms of estimator bias or test size distortions. Stock and Yogo provide critical values that depend on the number of endogenous regressors, the number of instruments, the maximum bias, the estimation procedure. Similar logic is proposed for the test size, but instead of controlling bias, it controls the size of a Wald test. Basically, both Staiger and Stock (1997) and Stock and Yogo (2005) tests reject the null hypothesis of weak instruments when the Cragg and Donald (1993) statistic exceeds a given threshold. This test statistic reduces to the first-stage F statistic in the case with a single endogenous regressor. Although the Cragg-Donald test is suited for more than one endogenous regressors, Table 6 shows also the Cragg-Donald statistic for our six specifications where one instrument is used for each endogenous regressor. The very high value of the statistic exceeds the Stock-Yogo critical values confirming that none of the instruments used are weak.

We mentioned before that the endogeneity test could be invalid if heteroskedasticity is present. The logic of using the first-stage F statistics relies heavily on the assumption of conditional homokedasticity. Montiel Olea and Pflueger (2013) propose a test for weak instruments that allows for errors that are not conditionally homoskedastic and serially uncorrelated. It extends the Stock and Yogo (2005) weak instrument tests for both 2SLS and Limited Information Maximum Likelihood (LIML) with a single endogenous regressor. Differently from Staiger and Stock (1997) and Stock and Yogo (2005), which test for weak instruments under the assumption of conditionally homoskedastic and serially uncorrelated model errors, Montiel Olea and Pflueger test is robust for heteroskedasticity, autocorrelation, and clustering. It uses use the standard Nagar (1959) methodology to obtain a tractable proxy for the asymptotic estimator bias. The Nagar bias is always defined and bounded for both TSLS and LIML. Montiel Olea and Pflueger define the null hypothesis of weak instruments such that the Nagar bias may be large. Under the alternative hypothesis, the Nagar bias is bounded relative to the benchmark. The benchmark captures the "worst-case" situation when instruments are completely uninformative and when first- and second-stage errors are perfectly correlated. The null hypothesis is that the Nagar bias exceeds a fraction τ of the benchmark for at least some value of the structural parameter and some direction of the first stage coefficients. On the other hand, under the alternative, the Nagar bias is at most a fraction τ of the benchmark for any values for the structural parameter and for any direction of the first stage coefficients. The robust weak instrument test rejects the null hypothesis of weak instruments when the test statistic, the effective F statistic, exceeds a critical value. In the just-identified case with one instrument, the effective F statistic equals the robust F statistic, but in general it differs from both the non-robust F and the robust F statistic. The critical value depends on the significance level α, the desired threshold τ, the estimated variance-covariance matrix and on the estimator (2SLS or LIML). Table 6 includes Montiel-Pflueger effective F-statistics. The high value of the statistic allows us to reject the null-hypothesis of weak instrument with a 5% significance level.

Lastly, we perform the Durbin-Wu-Hausman (DWH) test for endogeneity of regressors. According to Baum et al. (2002) a Hausman statistic for a test of endogeneity in an IV regression is formed by choosing OLS as the efficient estimator and IV as the inefficient but consistent estimator. The test should not interpreted as a test for the endogeneity or exogeneity of regressors per se, but rather as a test of employing different estimation methods on the same equation. The null-hypothesis is that the residual is zero and that therefore the variable being instrumented is exogenous and IV are non needed. As shown in Table 6 the DHW always rejects the null-hypothesis, concluding that the current road measure is endogenous and the IV estimator is required.

We also perform 2SLS estimation using both Roman roads and elevation (ELEV) as instruments in the first stage.

First stage (two instruments):

$$CR_i = \delta_0 + \delta_1 RR_i + \delta_2 ELEV_i + \delta_3 \boldsymbol{X}_i + \eta_s + v_i$$

Second stage:

$$\tau_{i\,t} = \alpha_0 + \alpha_1 \widehat{CR}_i + \alpha_2 \boldsymbol{X}_i + \eta_s + \gamma_t + \varepsilon_{it}$$

Recent literature demonstrates that physical obstacles makes it harder to build transport infrastructure (Del Bo and Florio, 2012) and that geographical variables perform well as instrumental variables in IV approach: they are correlated with the infrastructure, but not directly linked to the economic dependent variable. Table 7 shows our estimation results. Highly significant coefficients and expected signs are confirmed for all six overidentified models. The large value of the first stage F-statistics ("rule-of-thumb" diagnostic) and of the Cragg-Donald F-statistics, testing for weak instruments, lead to reject the null hypothesis of weak instruments. Since the detection of heteroskedastic disturbance (Pagan-Hall P-value equals to 0 in all specifications), we perform the Montiel Olea and Pflueger test for weak instruments robust for heteroskedasticity: the effective F-statistics widely exceed the critical value confirming the absence of weak instruments. The DHW test suggests the need of an IV approach. Lastly, we test for the failure of the exclusion restriction. The Hansen's test always rejects the joint null hypothesis that the instruments are valid instruments. This result is due to the elevation variable. The first-stage coefficient of elevation is always not significant, whereas Roman roads measure performs quite well (first-stage coefficient is always highly significant).

We also present a robustness exercise using cross-section rather than panel data to calculate the mean of our indirect measure of trade costs. Table B3 in Appendix B provides IV estimation results for cross-sectional data.

7. Conclusions

This paper investigated whether the existence of the ancient Roman road network played a role in the current trade attitude of Italian provinces, analyzing how deep and strong are the effects of past historical episodes in shaping actual economics outcomes, examining the persistence of the old infrastructure on the present one and providing evidence on how good institutions and investments in infrastructure projects are fundamental in determining, not only current economic results, but also future incomes.

We proceeded exploiting two different empirical strategies. We first focused on the pure and comprehensive effect of the Roman road system, according to that strand of literature which stresses the long-term effect of historical facts through institutions, infrastructures and geography. We disregarded in this stage those mechanisms through which the Roman network performed. In the second step we deepened the analysis. Aimed at the cause of persistence, we observed the current Italian infrastructure as the channel through which the Roman roads affect actual trade costs. In order to control for persisting differences across provinces, we used some geographical and weather variables and a double set of historical controls.

We find robust evidence of a negative effect of an integrated ancient road system on the current trade costs measure. These results are confirmed when considering also minor or uncertain roads, when using the Roman roads measure in a dichotomous way and when looking at the EU15 market rather than the world market. Moreover, robustness checks using a higher elasticity of substitution for the trade costs measure confirm strongly the significance, the sign and the magnitude of the estimates.

The evidence from the first analysis suggests that provinces with a large Roman road network have a propensity to have more trade relations abroad rather than with themselves. The reasonable key idea behind this is that the Roman road system is affected by persistence. This persistence performed through several advantages and benefits. A denser transportation network enabled more developed and urbanized settlements, more active and functioning cities, more economic activities and trade. This has led to more contacts and relationships between people, shaping a more open mentality and a higher propensity to engage with different peoples and cultures, as it was during the Roman empire. In this perspective, it can be argued that the Roman road system had not only an active part in reducing physical distances, but also a key role in shaping human mind.

The instrumental variable method is more inspired to the ‘physical’ rather than to the ‘openness’ concern, proposing how for provinces with a lengthier and denser Roman network the old infrastructure has represented a good starting point and a base for the new infrastructure. Further research on this subject will be at the heart of future work.

The evidence produced gives the impression that both ‘physical’ and ‘mental’ subjects come along the same conclusion: the Roman empire with its aim of expansion, development and growth, with its engineering abilities and military capacities, with its well structured organization and effective systems, with its culture and advanced knowledge had a so deep, strong and lasting effect on a so huge variety of concerns, that past facts and old history should not be underestimated and should be considered in providing guidance for policy.

REFERENCES

Acemoglu D., Johnson S. and Robinson J.A. (2001) The Colonial Origins of Comparative Development: An Empirical Investigation, The American Economic Review, 91, 5, 1369-1401.

Acemoglu D., Johnson S. and Robinson J.A. (2002) Reversal of fortune: Geography and institutions in the making of the modern world income distribution, Quarterly Journal of Economics, 1231-1294.

Anderson J.E. and van Wincoop E. (2004) Trade Costs, Journal of Economic Literature, 42, 3, 691-751.

Anderson J.E. and Yotov Y. (2012) Gold standard gravity, NBER Working Paper, w17835.

Aschauer D.A. (1990) Why is infrastructure important?, Conference Series, Federal Reserve Bank of Boston, 34, 21-68.

Automobile Club Italia (2011) Dotazione di infrastrutture stradali sul territorio italiano, available at http://www.aci.it/fileadmin/documenti/studi_e_ricerche/dati_statistiche/Infrastrutture_stradali_in_Italia/Dotazione_di_infrastrutture_stradali_in_Italia.pdf (accessed 25 July 2016).

Baier S.L. and Bergstrand J.H. (2001) The Growth of World Trade: Tariffs, Transport Costs and Income Similarity, Journal of International Economics, 53, 1, 1-27.

Banerjee A., Duáo E. and Qian N. (2012) On the Road: Access to Transportation Infrastructure and Economic. Growth in China, NBER Working Paper N. 17897.

Baum C.F., Schaffer M.E. and Stillman S. (2003) Instrumental variables and GMM: Estimation and testing, The Stata Journal, 3, 1, 1-31.

Bleaney M. and Dimico A. (2014) Geography Matters: Reconsidering the Effect of Geography on Development. Nottingham: Unpublished Credit Research Paper

Bloom D. E. and Williamson J.G. (1997) Demographic Transitions and Economic Miracles in Emerging Asia, World Bank Economic Review, 12.

Chevallier R. (1976) Romand Roads, trans. N.H. Field, Berkeley: University of California press, 1976.

Cragg J.G. and Donald S.G. (1993) Testing identifiability and specification in instrumental variable models, Econometric Theory, 9, 222-240.

Davies H.E.H. (1998) Designing Roman Roads, Britannia, 29, 1-16.

Dalgaard C.J., Kaarsen N., Olsson O. and Selaya P. (2015) Roman Roads to Prosperity: The Long-run Impact of Transport Infrastructure, SLIDE PRESENTATION available at http://economics.gu.se/digitalAssets/1531/1531740_roman4.pdf (accessed 01 December 2015).

Duval Y. and Utoktham C. (2011) Intraregional Trade Costs in Asia: A Primer, Asia-Pacific Development Journal, 18, 2, 1-23

De Benedictis L. and Pinna A.M. (2015) Islands as "bad geography" - Insularity, Connectedness, Trade Costs and Trade, Working Paper Crenos 2015/04.

Del Bo C.F., and Florio M. (2012) Infrastructure and Growth in a Spatial Framework: Evidence from the EU regions, European Planning Studies 20(8), 1393-1414.

Di Liberto A. and Sideri M. (2015) Past dominations, current institutions and the Italian regional economic performance, European Journal of Political Economy, Elsevier, 38(C), 12-41.

Diamond J. (1997) Guns, Germs and Steel: The Fates of Human Societies, Norton.

Dunn R.S. (1972) Sugar and Slaves: The Rise of the Planter Class in the English West Indies. 1624-1713, Chapel Hill: University of North Carolina Press.

Donaldson D. (2012) Railroads of the Raj: Estimating the Impact of Transportation Infrastructure American Economic Review, forthcoming.

Eaton J. and Kortum S. (2002) Technology, Geography, and Trade, Econometrica, 70, 5, 1741-1779.

Engerman S.L. and Sokoloff K.L. (1997) Factor endowments, institutions, and differential paths of growth among New World economies: a view from economic historians of the United States. In How Latin America Fell Behind, ed. S Harber, Stanford, CA: Stanford University Press, 260–304.

Engerman S.L. and Sokoloff K.L. (2000) Institutions, Factor Endowments, and Paths of Development in the New World, Journal of Economic Perspectives, 14, 3, 217–232.

Engerman S.L. and Sokoloff K.L. (2002) Factor Endowments, Inequality, and Paths of Development Among New World Economies, Journal of the Latin American and Caribbean Economic Association, 3, 1, 41-110

Feenstra R.C. (1994) New Product Varieties and the Measurement of International Prices, American Economic Review, 84, 1, 157-177.

Finley M.I. (1973) The Ancient Economy, London.

Gleason J.P. (2013) Roman Roads in Gaul: How Lines of Communication and Basing Support Operational Reach, School of Advanced Military Studies Monographs

Hall R.E. and Jones C.I. (1999) Why Do Some Countries Produce So Much More Output per Workers than Others? Quarterly Journal of Economics, 114, 1, 83-116.

Harrigan J. (1993) OECD Imports and Trade Barriers in 1983, Journal of International Economics, 35, 1-2, 91–111.

Head K. and Ries J. (2001) Increasing Returns vs National Product Differentiation as an Explanation for the Pattern of US-Canada Trade, American Economic Review, 91, 4, 858-76.

Hodgson G.M. (2006) What are institutions?, Journal of Economic Issues, 40, 1, 1-26.

Hoekman B. and Nicita A. (2008) Trade Policy, Trade Costs, and Developing Country Trade, World Bank Policy Research Working Paper Series, 47-97.

Hummels D. (1999) Toward a Geography of Trade Costs, GTAP Working Papers 1162, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Jacks D., Meissner C.M. and Novy D. (2008) Trade Costs, 1870-2000, American Economic Review: Papers & Proceedings, 98, 2, 529-534.

Jacks D., Meissner C.M. and Novy D. (2010) Trade Costs in the First Wave of Globalization, Explorations in Economic History, 47, 2, 127-141.

Jacks D., Meissner C.M. and Novy D. (2011) Trade Booms, Trade Busts and Trade Costs, Journal of International Economics, Elsevier, 83, 2, 185-201.

Kessides C. (1993) The contributions of infrastructure to economic development : a review of experience and policy implications, World Bank discussion papers , No.WDP 213, Washington, DC: The World Bank.

Knack S. and Keefer P. (1995) Institutions and Economic Performance: Cross-Country Test Using Alternatives Measures, Economics and Politics, 7, 3, 207-227.

Knapton J. (1996) The Romans and their roads - The original small element pavement technologists, Pave Israel 96, 26.

Knight F.W. (1990) The Caribbean: The Genesis of a Fragmented Nationalism. New York: Oxford University Press.

Knight J. (1992) Institutions and Social Conflict, Cambridge: Cambridge University Press.

La Porta, R., Lopez-de-Silanes F. and Shleifer, A. (1999) The Quality of Government, Journal of Law, Economics, and Organization, 15, 222-279.

La Porta, R., Lopez-de-Silanes F. and Shleifer, A. (2008) The Economic Consequences of Legal Origins, Journal of Economic Literature, 46, 285-332.

Laurence R. (1999) The Roads of Roman Italy: Mobility and Cultural Change, London.

Limao N. and Venables, A. (2001) Infrastructure, Geographical Disadvantage, Transport Costs, and Trade, World Bank Economic Review, 15.

McCormick M., Huang G., Zambotti G. and Lavash J. (2013) Roman Road Network (version 2008). DARMC Scholarly Data Series. Data Contribution Series 2013-5.

Moïsé E. and Le Bris F. (2013) Trade Costs - What Have We Learned?: A Synthesis Report, OECD Trade Policy Papers, No. 150, OECD Publishing.

Montiel Olea J.L. and Pflueger C.E. (2013) A robust test for weak instruments, Journal of Business and Economic Statistics, 31, 358-369.

Moreno Fraginals M. (1976) The Sugarmill: The Socioeconomic Complex of Sugar in Cuba, New York: Monthly Review Press.

Nagar A. (1959) The bias and moment matrix of the general k-class estimators of the parameters in simultaneous equations, Econometrica, 27, 575-595.

North D. (1981) Structure and Change in Economic History, Norton, New York.

North D. (1988) Institutions, Transaction Costs and Economic Growth, Economic Inquiry, 25.

North D. (1989) Institutions and Economic Growth: An Historical Introduction, World Development, 17, 9, 1319-1332.

Novy D. (2013) Gravity redux: measuring international trade costs with panel data, Economic Inquiry, 51, 1, 101-121.

Nunn N. (2009) The Importance of History for Economic Development, Annual Review of Econonomics, 1, 1, 65-92.

Obstfeld M. and Rogoff K. (2000) The Six Major Puzzles in International Economics: Is There a Common Cause?, NBER Working Paper, No. 7777.

Olea J.L.M. and Pflueger C. (2013) A Robust Test for Weak Instruments, Journal of Business and Economic Statistics 31, 358-368.

Olsson O. and Hibbs D. Jr. (2005) Biogeography and long-run economic development, European Economic Review, 49, 4, 909-938.

Pawson E. (1977) Transport and Economy: the Turnpike Roads of Eighteenth Century Britain, London.

Roth J.P. (1999) The logistics of the Roman army at war (264 B.C.-A.D. 235), Columbia Studies in the Classical Tradition, 23, Brill.

Rymer Eric (2002) Roman Trade Routes, available at http://www.historylink102.com/Rome/roman-ships.htm (accessed 25 July 2016).

Sachs J.D. (2003) Institutions Don't Rule: Direct Effects of Geography on Per Capita Income, NBER Working Paper 9490, National Bureau of Economic Research Inc.

Sheridan R. (1974) Sugar and Slavery: An Economic History of the West Indies. 1623-1775, Aylesbury: Ginn and Company.

Snedden R. (1998) Technology in the Time of Ancient Rome, Austin, Tex.: Raintree Steck-Vaughn.

Schwartz S.B. (1985) Sugar Plantations in the Formation of Brazilian Society: Bahia. 1550-1835, Cambridge: Cambridge University Press.

Smith W. (1890) A Dictionary of Greek and Roman Antiquities, London: John Murray, 1890, Spolaore E. and Wacziarg R. (2013) How Deep Are the Roots of Economic Development?, Journal of Economic Literature, 51, 2, 325-369.

Staiger D. and Stock J.H. (1997) Instrumental variables regression with weak instruments, Econometrica, 65, 3, 557-586.

Stock J.H. and Yogo M. (2005) Testing for weak instruments in linear IV regression, in Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg, Cambridge University Press, 80-108.

Tabellini G. (2010) Culture and Institutions: Economic Development in the Regions of Europe. Journal of the European Economic Association, 8, 677-716.

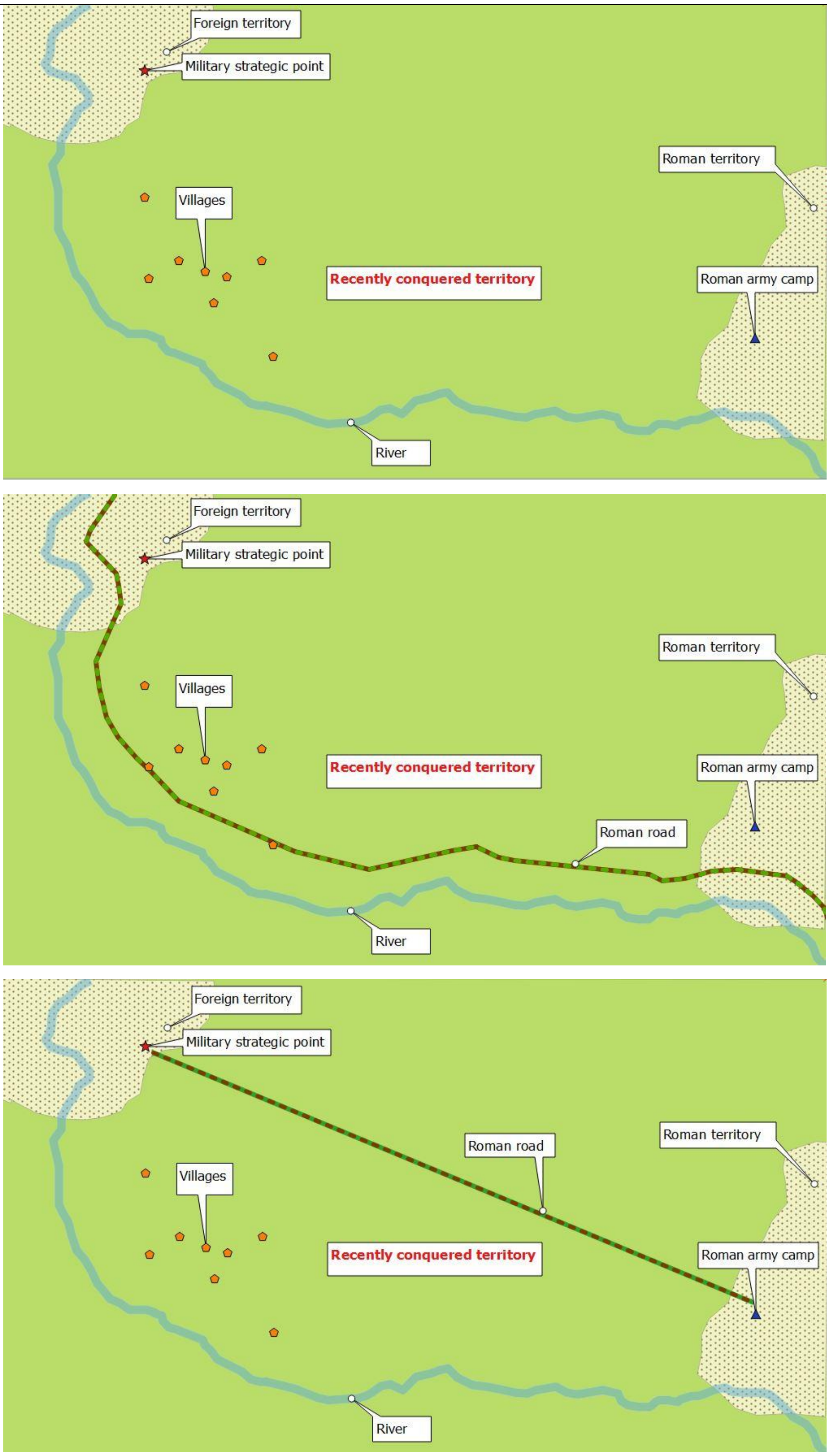
Thompson L. (1997) Roman roads, History Today 47, 2.

Valencia Caicedo F. (2014) The Mission: Economic Persistence, Human Capital Transmission and Culture in South America, mimeo.

Volpe Martincus C., Carballo J. and Cusolito A. (2014) Routes, Exports, and Employment in Developing Countries: Following the Trace of the Inca Roads, mimeo.

Wahl F. (2015) The long shadow of history: Roman legacy and economic development - evidence from the German limes, Hohenheim Discussion Papers in Business, Economics and Social Sciences 08-2015.

Figure 1 Roman road construction



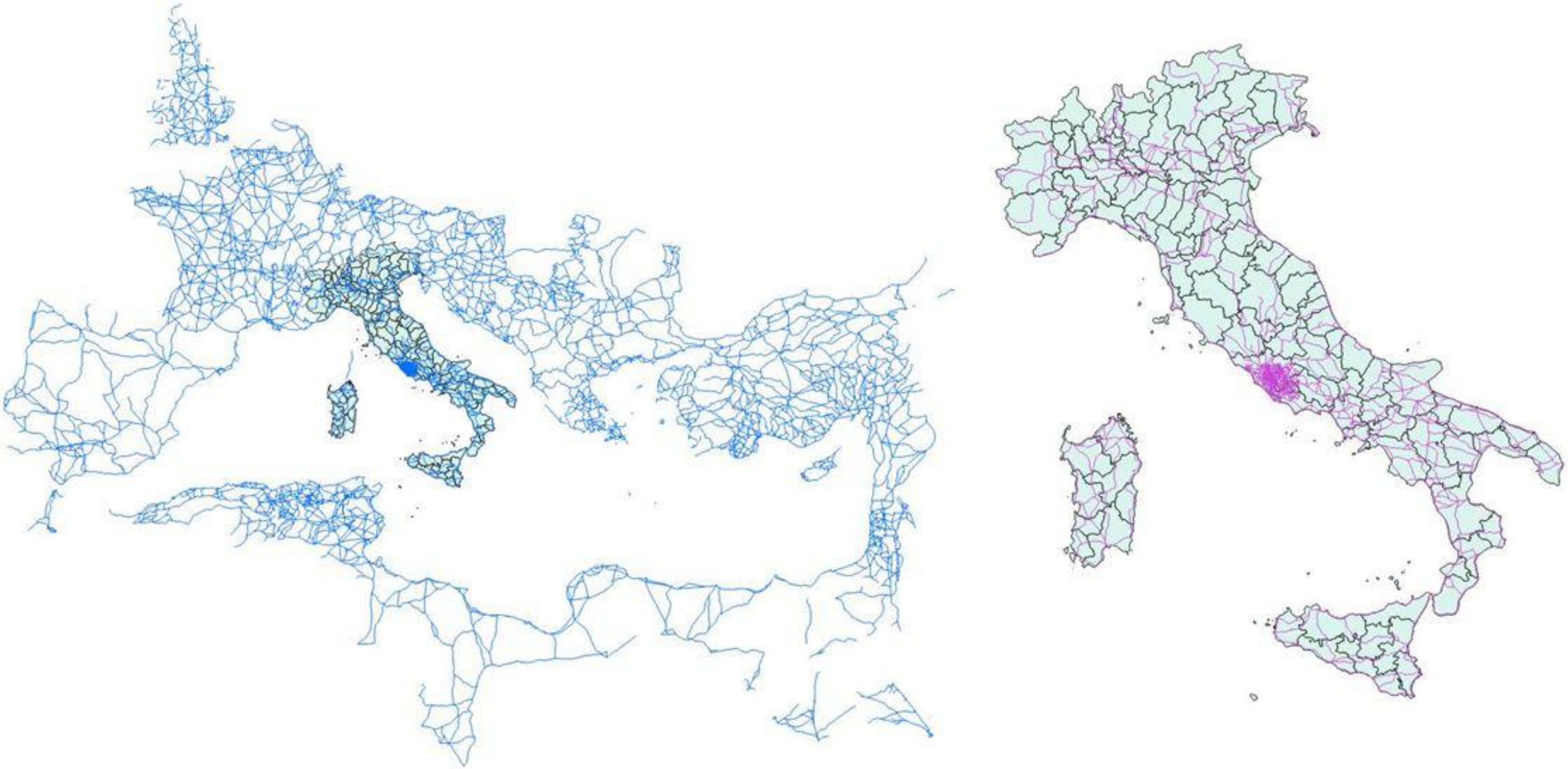
1.
Starting situation

2.
Not typical Roman choice. Road construction endogenous to development

3.
Typical Roman choice. Road construction exogenous to development

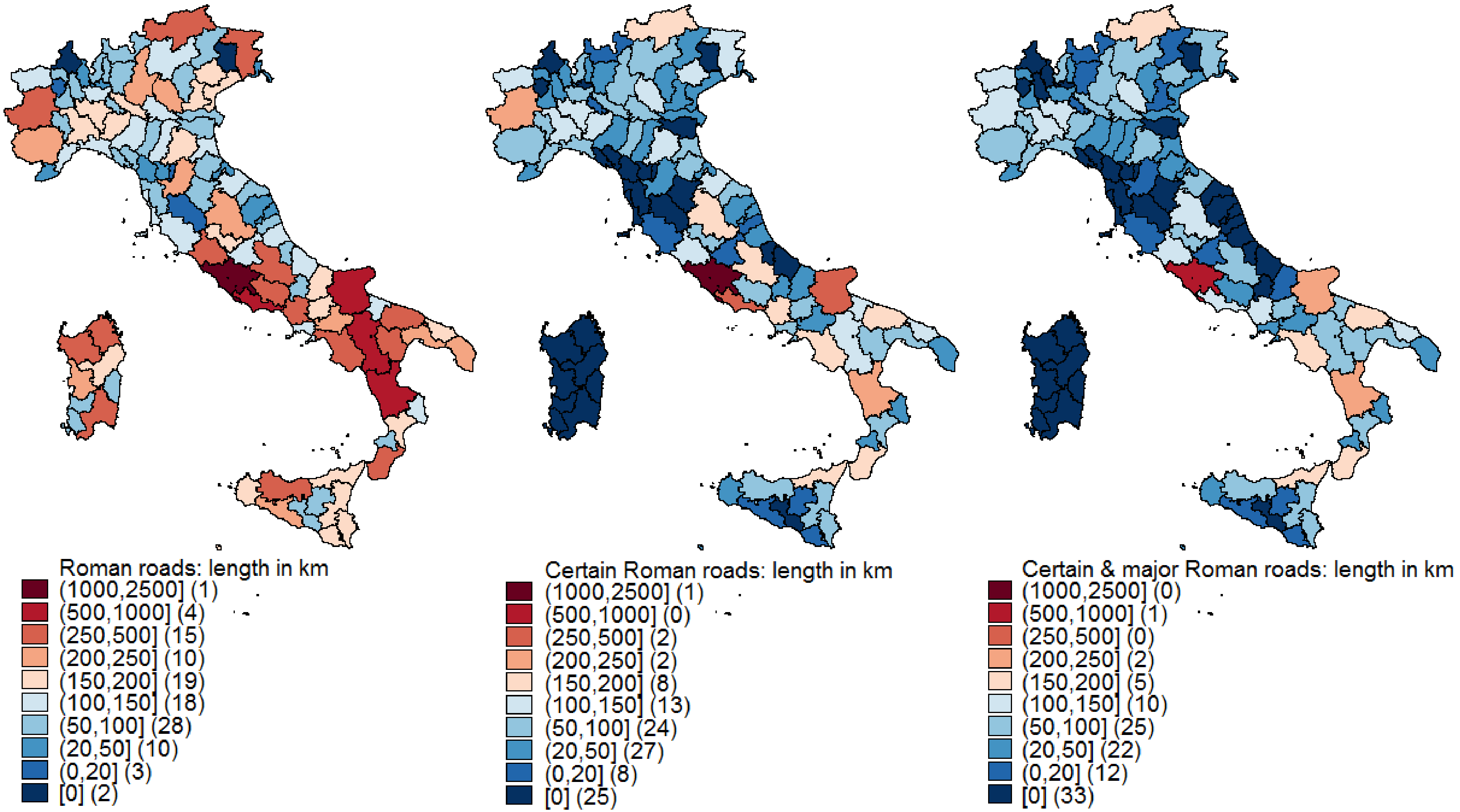
Source: Own draw from original idea of Dalgaard et al. (2015) Roman Roads to Prosperity: The Long-run Impact of Transport Infrastructure

Figure 2 Roman Roads at peak of empire (117 CE)



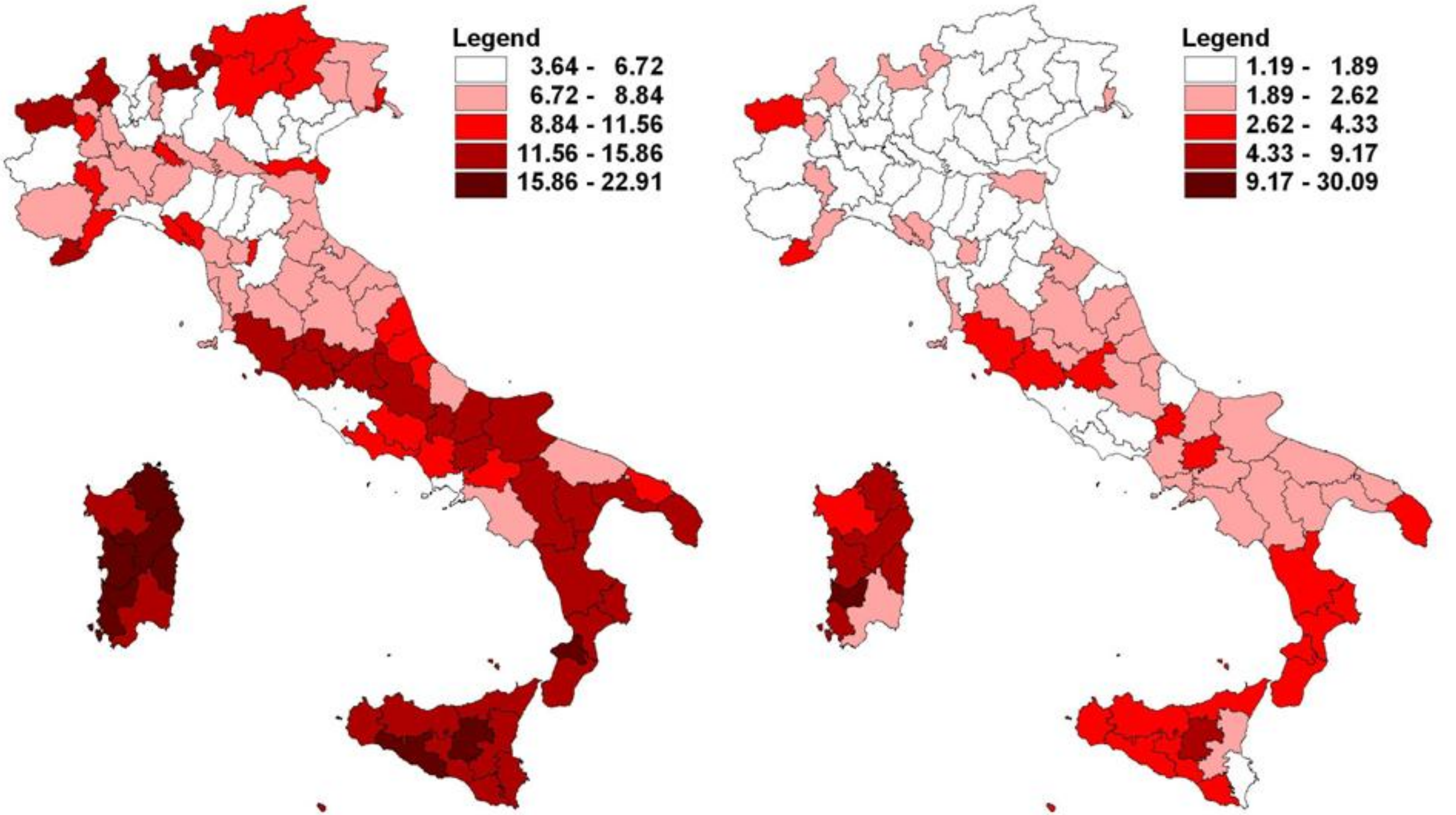
Source: Own elaboration from McCormick, M. et al. 2013. "Roman Road Network (version 2008)", DARMC Scholarly Data Series 2013-5 and from ISTAT (2011)

Figure 3 Roman roads in length by Italian province



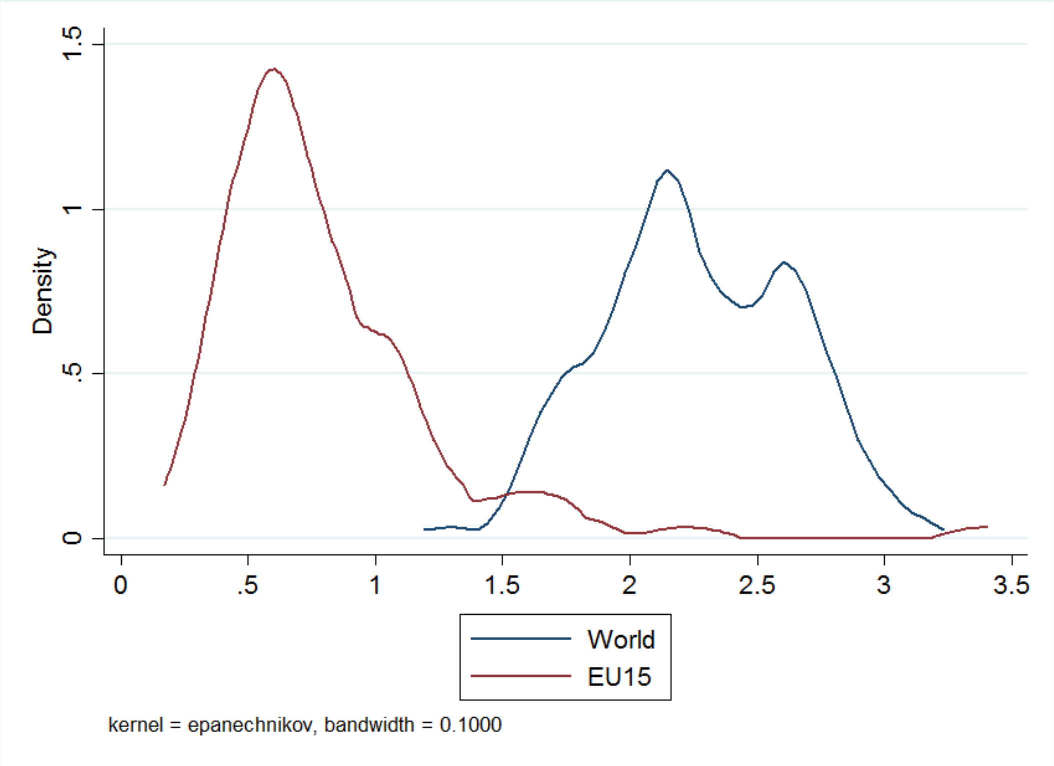
Source: Own elaboration from McCormick, M. et al. 2013. "Roman Road Network (version 2008)", DARMC Scholarly Data Series 2013-5

Figure 4 Italian provincial trade costs, all the world (left) and EU15 (right), 2010



Source: Own elaboration from Istat and World Bank data

Figure 5 Kernel distribution of aggregated Italian provincial trade costs



Source: Own elaboration from Istat and World Bank data

Table 1: Trade costs in the four major socio-economic Italian regions in 2003 and 2010

	2003			2010		
Major socio-economic Italian regions (NUTS1)	Tij with σ=11	Tij with σ=8	Tij with σ=7	Tij with σ=11	Tij with σ=8	Tij with σ=7
North-east	3.11	7.16	11.17	3.15	7.31	11.47
North-west	3.42	8.09	12.83	3.52	8.43	13.48
Centre	3.55	8.40	13.33	3.78	9.16	14.73
South	4.90	12.45	20.53	5.29	13.77	23.00

Source: Own elaboration from Istat and World Bank data

Table 2 Estimation results considering only certain Roman roads, world market, σ=8

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel estimates				Cross-section estimates			
Certain Roman roads km (log)	-0.111***	-0.097***	-0.090***		-0.111***	-0.098***	-0.090***	
Certain Roman roads (binary)				-0.131**				-0.033
Elevation (log)	-0.050	-0.084**	-0.106**	-0.092**	-0.050	-0.084*	-0.106*	-0.100**
Average temperature	-0.042	-0.072***	-0.076***	-0.055**	-0.042	-0.072***	-0.076**	-0.062**
Coast (binary)	0.043	0.065	0.024	-0.040	0.043	0.064	0.024	-0.032
Austria (binary)	0.078		0.182	0.362	0.078		0.182	0.280
Papal State (binary)	-0.157**		-0.233**	-0.080	-0.158*		-0.234*	-0.066
Savoy (binary	-0.136		0.777***	0.370	-0.135		0.778***	0.401
Spain (binary)	-0.085		-0.043	0.127	-0.084		-0.042	0.078
Venice (binary)	-0.151		-0.002	0.071	-0.150		-0.001	0.035
Normans (years)		-0.011***	-0.012***	-0.008***		-0.011***	-0.012***	-0.006**
Swabians (years)		0.000	0.000	-0.001		0.000	0.000	-0.001
Anjou (years)		0.000	-0.000	-0.000		0.000	-0.000	-0.000
Spain (years)		-0.000	0.000***	-0.000		-0.000	0.000***	-0.000
Bourbons (years)		0.011***	0.011***	0.013***		0.011***	0.011***	0.012***
Papal State (years)		0.000	0.000	0.000		0.000	0.000	0.000
Venice (years)		-0.001***	-0.001***	-0.001*		-0.001***	-0.001**	-0.001*
Austria (years)		-0.000	-0.000	-0.001*		-0.000	-0.000	-0.001
Savoy (years)		-0.001*	-0.002***	-0.001***		-0.001	-0.002***	-0.001**
Constant	4.186***	4.960***	5.098***	4.132***	3.747***	3.910***	4.227***	4.162***
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	-	-	-	-
Dummy north/south	YES	YES	YES	YES	YES	YES	YES	YES
Observations	664	664	664	820	83	83	83	103
R-squared	0.729	0.779	0.801	0.742	0.734	0.785	0.807	0.744

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table 3 Estimation results considering only certain and major Roman roads, world market, σ=8

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel estimates				Cross-section estimates			
Certain & major Roman roads km (log)	-0.120***	-0.092***	-0.078***		-0.120***	-0.092***	-0.078**	
Certain & major Roman roads (binary)				-0.033				-0.033
Elevation (log)	-0.023	-0.091*	-0.111**	-0.100**	-0.023	-0.091	-0.110	-0.100**
Average temperature	-0.029	-0.074***	-0.078***	-0.062***	-0.028	-0.074***	-0.078**	-0.062**
Coast (binary)	0.099	0.033	-0.035	-0.032	0.098	0.033	-0.035	-0.032
Austria (binary)	0.110*		0.070	0.281	0.110		0.070	0.280
Papal State (binary)	-0.110		-0.340**	-0.066	-0.110		-0.341	-0.066
Savoy (binary	-0.122		-4.494	0.403	-0.122		-4.498	0.401
Spain (binary)	0.003		1.631	0.077	0.004		1.633	0.078
Venice (binary)	-0.077		-0.050	0.035	-0.076		-0.049	0.035
Normans (years)		-0.006***	-0.064	-0.006**		-0.006***	0.003	-0.006**
Swabians (years)		0.000	0.000	-0.001		0.000	0.000	-0.001
Anjou (years)		0.000	0.000	-0.000		0.000	0.000	-0.000
Spain (years)		-0.001**	-0.009	-0.000		-0.001*	-0.009	-0.000
Bourbons (years)		0.015***	0.037*	0.012***		0.015***	0.037	0.012***
Papal State (years)		0.001	0.001**	0.000		0.001	0.001*	0.000
Venice (years)		-0.001***	-0.001**	-0.001**		-0.001**	-0.001	-0.001*
Austria (years)		0.000	-0.000	-0.001		0.000	-0.000	-0.001
Savoy (years)		-0.002***	-0.003***	-0.001**		-0.002***	-0.003***	-0.001**
Constant	3.375***	4.315***	10.370**	4.367***	3.542***	4.299***	2.783	4.162***
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	-	-	-	-
Dummy north/south	YES	YES	YES	YES	YES	YES	YES	YES
Observations	608	608	608	820	76	76	76	103
R-squared	0.717	0.779	0.791	0.736	0.722	0.784	0.797	0.744

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table 4 Estimation results considering all Roman roads, world market, σ=8

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel estimates				Cross-section estimates			
All Roman roads km (log)	-0.104***	-0.110***	-0.103***		-0.104**	-0.110***	-0.104***	
All Roman roads (binary)				0.149				0.149
Elevation (log)	-0.069	-0.107***	-0.116***	-0.103***	-0.069	-0.106***	-0.116**	-0.103**
Average temperature	-0.046*	-0.077***	-0.083***	-0.069***	-0.046	-0.077***	-0.083***	-0.070**
Coast (binary)	0.019	0.023	0.019	-0.035	0.019	0.023	0.019	-0.035
Austria (binary)	0.071		0.074	0.108	0.071		0.074	0.107
Papal State (binary)	-0.090		-0.026	-0.064	-0.091		-0.026	-0.064
Savoy (binary	-0.115		0.713***	0.390	-0.114		0.711**	0.389
Spain (binary)	-0.052		-0.017	0.004	-0.050		-0.014	0.006
Venice (binary)	-0.102		-0.010	-0.048	-0.101		-0.008	-0.048
Normans (years)		-0.009***	-0.010***	-0.006***		-0.009***	-0.010***	-0.006**
Swabians (years)		0.000	-0.000	-0.001		0.000	-0.000	-0.001
Anjou (years)		0.001	0.000	-0.001		0.001	0.000	-0.001
Spain (years)		-0.000	0.000**	-0.000		-0.000	0.000*	-0.000
Bourbons (years)		0.012***	0.012***	0.011***		0.012***	0.012***	0.011***
Papal State (years)		0.000	0.000	0.000		0.000	0.000	0.000
Venice (years)		-0.001**	-0.001**	-0.001**		-0.001*	-0.001	-0.001
Austria (years)		-0.000	-0.000	-0.000		-0.000	-0.000	-0.000
Savoy (years)		-0.001*	-0.002***	-0.002***		-0.001	-0.002***	-0.002**
Constant	3.896***	4.903***	5.128***	4.232***	3.925***	4.930***	4.487***	4.224***
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	-	-	-	-
Dummy north/south	YES	YES	YES	YES	YES	YES	YES	YES
Observations	804	804	804	820	101	101	101	103
R-squared	0.703	0.762	0.774	0.737	0.710	0.770	0.781	0.744

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table 5 Estimation results considering only major Roman roads, world market, σ=8

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel estimates				Cross-section estimates			
Major Roman roads km (log)	-0.059*	-0.065**	-0.067**		-0.059	-0.065*	-0.067	
Major Roman roads (binary)				0.126*				0.127
Elevation (log)	-0.064	-0.099***	-0.111***	-0.103***	-0.064	-0.099**	-0.111**	-0.102**
Average temperature	-0.042	-0.074***	-0.087***	-0.069***	-0.042	-0.074***	-0.087***	-0.069***
Coast (binary)	0.009	0.000	0.001	-0.054	0.009	-0.000	0.001	-0.054
Austria (binary)	0.048		-0.079	0.115	0.049		-0.079	0.114
Papal State (binary)	-0.075		-0.034	-0.093	-0.076		-0.034	-0.094
Savoy (binary	-0.102		0.814***	0.414	-0.102		0.815**	0.413
Spain (binary)	-0.088		-0.137	0.024	-0.087		-0.137	0.025
Venice (binary)	-0.174		-0.141	-0.053	-0.173		-0.140	-0.053
Normans (years)		-0.009***	-0.009***	-0.006***		-0.009***	-0.009***	-0.006**
Swabians (years)		-0.000	-0.000	-0.001		-0.000	-0.000	-0.001
Anjou (years)		0.000	0.000	-0.001		0.000	0.000	-0.001
Spain (years)		-0.000	0.000***	-0.000		-0.000	0.000**	-0.000
Bourbons (years)		0.012***	0.011***	0.011***		0.012***	0.011***	0.011***
Papal State (years)		0.001*	0.001*	0.001*		0.001	0.001	0.001
Venice (years)		-0.001**	-0.001*	-0.001*		-0.001*	-0.001	-0.001
Austria (years)		-0.000	0.000	-0.000		-0.000	0.000	-0.000
Savoy (years)		-0.001	-0.003***	-0.002***		-0.001	-0.003***	-0.002**
Constant	3.381***	3.735***	4.000***	4.230***	3.364***	3.715***	3.980***	4.217***
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	-	-	-	-
Dummy north/south	YES	YES	YES	YES	YES	YES	YES	YES
Observations	736	736	736	820	92	92	92	103
R-squared	0.653	0.722	0.744	0.740	0.659	0.728	0.750	0.747

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table 6 Estimation results with Instrumental Variables (IV) approach (panel data, one instrument)

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)
Total current roads km (log)	-0.513***	-0.423***	-0.301***			
Motorways (log)				-0.264***	-0.231***	-0.112***
Elevation (log)	-0.065***	-0.094***	-0.054***	-0.090***	-0.097***	-0.097***
Average temperature	-0.067***	-0.079***	-0.057***	-0.047***	-0.052***	-0.055***
Coast (binary)	-0.060**	-0.104***	-0.003	-0.052**	-0.073***	-0.049**
Normans (years)	-0.019***	-0.021***	-0.013***	-0.035***	0.004**	-0.025***
Swabians (years)	0.001*	0.001*	0.001	0.001	0.000	0.000
Anjou (years)	0.003***	0.003***	0.002***	-0.000	-0.000	-0.000
Spain (years)	0.000	-0.000**	-0.000	0.000**	-0.000	-0.000
Bourbons (years)	0.018***	0.020***	0.015***	0.054***	0.063***	0.041***
Papal State (years)	-0.000	0.000**	0.000	0.001***	0.001***	0.001***
Venice (years)	0.000	-0.000	-0.000**	0.000	-0.000	-0.000***
Austria (years)	-0.001***	-0.001***	-0.001***	0.000	0.000	0.000
Savoy (years)	-0.000	-0.002***	-0.001***	-0.000**	-0.001***	-0.001***
Constant	8.311***	8.382***	6.295***	4.818***	0.654	4.342***
Regional fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
Dummy north/south	YES	YES	YES	YES	YES	YES
Observations	664	608	804	576	528	648
R-squared	0.702	0.752	0.714	0.824	0.834	0.783
First-stage instrument coefficient	0.194***	0.215***	0.359***	0.428***	0.456***	0.590***
First-stage F-statistics	189.70	231.38	120.79	240.88	237.89	326.27
Durbin-Wu-Hausman P-value	0.000	0.000	0.000	0.008	0.443	0.000
Cragg-Donald Wald F-statisics	218.256	234.399	344.319	229.228	211.001	299.146
Montiel-Pflueger effective F-statistics	169.534	210.260	142.320	238.788	217.407	332.805
Pagan-Hall P-value	0.000	0.000	0.000	0.000	0.000	0.000
Instrument	Certain Roman roads	Certain & major Roman roads	All Roman roads	Certain Roman roads	Certain & major Roman roads	Major Roman roads

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table 7 Estimation results with Instrumental Variables (IV) approach (panel data, two instruments)

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)
Total current roads km (log)	-0.574***	-0.489***	-0.345***			
Motorways (log)				-0.291***	-0.272***	-0.134***
Average temperature	-0.045***	-0.047***	-0.038***	-0.006	-0.006	-0.015***
Coast (binary)	-0.040	-0.065**	0.019	-0.018	-0.039*	-0.004
Normans (years)	-0.018***	-0.020***	-0.014***	-0.040***	0.009***	-0.025***
Swabians (years)	0.001*	0.001	0.001	0.001	0.000	0.000
Anjou (years)	0.003***	0.003***	0.002***	-0.001***	-0.001***	-0.001**
Spain (years)	0.000*	-0.000	-0.000	0.000***	0.000*	-0.000
Bourbons (years)	0.016***	0.017***	0.014***	0.063***	0.074***	0.042***
Papal State (years)	-0.000**	0.000	0.000	0.001***	0.001***	0.001***
Venice (years)	0.000**	0.000	-0.000	0.000**	0.000	-0.000
Austria (years)	-0.001***	-0.001***	-0.001***	0.000	0.000	0.000
Savoy (years)	-0.000	-0.001***	-0.001***	0.000	0.000	-0.000***
Constant	8.014***	7.776***	5.934***	3.569***	-1.858***	3.072***
Regional fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
Dummy north/south	YES	YES	YES	YES	YES	YES
Observations	664	608	807	576	528	648
R-squared	0.668	0.717	0.687	0.802	0.815	0.77
First-stage F-statistics	169.530	210.260	142.320	238.790	217.410	332.810
Hansen P-value	0.000	0.000	0.000	0.000	0.000	0.000
Durbin-Wu-Hausman P-value	0.000	0.000	0.000	0.000	0.024	0.000
Cragg-Donald Wald F-statisics	122.301	125.917	197.309	120.163	116.240	152.941
Montiel-Pflueger effective F-statistics	108.591	121.520	91.037	135.584	133.074	185.527
Pagan-Hall P-value	0.000	0.000	0.000	0.000	0.000	0.000
Instruments	Certain Roman roads and elevation	Certain & major Roman roads and elevation	All Roman roads and elevation	Certain Roman roads and elevation	Certain & major Roman roads and elevation	Major Roman roads and elevation

Note: Asterisks denote significance levels; * $p<0.10$, ** $p<0.05$ and *** $p<0.01$.

Appendix A - Old Roman roads and current roads by Province

Table A1: Kilometres of Roman roads by Italian Province

Italian Provinces	All Roman roads: length in km	All Roman roads: rank	Certain Roman roads: length km	Certain Roman roads: rank	Italian Provinces	All Roman roads: length in km	All Roman roads: rank	Certain Roman roads: length km	Certain Roman roads: rank
Roma	2498	1	1125	1	Ravenna	124	56	66	41
Latina	671	2	264	3	Crotone	117	57	49	52
Foggia	570	3	397	2	Mantova	116	58	51	50
Potenza	560	4	119	19	Aosta	113	59	113	23
Cosenza	531	5	249	4	Livorno	112	60	0	86
Salerno	427	6	169	9	Grosseto	110	61	4	84
Frosinone	386	7	91	31	Chieti	109	62	0	86
Olbia Tempio	379	8	0	86	Modena	107	63	28	70
Torino	366	9	211	5	Genova	105	64	78	35
Caserta	356	10	166	12	Pesaro-Urbino	103	65	103	26
L'Aquila	342	11	187	6	Parma	101	66	49	51
Bari	280	12	179	8	Savona	100	67	53	47
Viterbo	272	13	114	22	Lodi	100	68	8	81
Udine	271	14	126	15	Como	99	69	69	40
Bolzano	266	15	168	10	Calatanisetta	98	70	0	86
Palermo	265	16	96	28	Enna	93	71	9	80
Matera	261	17	53	46	Vercelli	91	72	41	56
Sassari	261	18	0	86	Isernia	90	73	31	66
Cagliari	255	19	0	86	Lecco	89	74	32	64
Reggio Calabria	251	20	185	7	Carbonia-Iglesias	86	75	0	86
Oristano	250	21	0	86	Ogliastra	86	76	0	86
Avellino	245	22	44	54	Ferrara	78	77	0	86
Perugia	238	23	155	13	Ascoli-Piceno	77	78	20	78
Agrigento	235	24	6	82	Rovigo	76	79	22	76
Firenze	229	25	39	59	Bergamo	76	80	40	58
Brescia	228	26	96	29	Arezzo	71	81	0	86
Lecce	210	27	32	65	Vibo-Valentia	70	82	24	75
Verona	206	28	120	18	Forlì-Cesena	69	83	52	48
Taranto	202	29	97	27	Medio-Campidano	69	84	0	86
Cuneo	200	30	72	39	Pisa	65	85	0	86
Campobasso	200	31	36	61	La Spezia	65	86	0	86
Treviso	198	32	117	21	Reggio-Emilia	62	87	62	42
Pavia	192	33	118	20	Asti	59	88	52	49
Trapani	188	34	41	57	Ancona	59	89	59	45
Bologna	184	35	110	24	Belluno	57	90	48	53
Nuoro	182	36	0	86	Sondrio	56	91	11	79
Brindisi	176	37	123	17	Pescara	54	92	0	86
Siracusa	176	38	85	33	Massa-Carrara	54	93	0	86
Venezia	176	39	29	69	Novara	52	94	25	74
Catanzaro	175	40	92	30	Vicenza	52	95	36	62
Catania	175	41	83	34	Rimini	49	96	29	68
Padova	173	42	37	60	Lucca	48	97	0	86
Messina	167	43	167	11	Trieste	44	98	27	72
Piacenza	166	44	125	16	Gorizia	41	99	41	55
Alessandria	164	45	126	14	Imperia	34	100	34	63
Ragusa	162	46	4	83	Pistoia	32	101	0	86
Cremona	161	47	74	37	Varese	27	102	27	71
Terni	153	48	78	36	Fermo	27	103	27	73
Benevento	151	49	61	43	Monza e della Brianza	23	104	0	86
Milano	148	50	74	38	Macerata	20	105	20	77
Trento	138	51	89	32	Siena	18	106	0	86
Barletta-Andria-Trani	137	52	108	25	Prato	10	107	0	86
Teramo	134	53	29	67	Biella	7	108	0	86
Napoli	129	54	60	44	Pordenone	0	109	0	86
Rieti	127	55	2	85	Verbano-Cusio-Ossola	0	109	0	86

Source: Own elaboration from McCormick, M. et al. 2013. "Roman Road Network (version 2008)," DARMC Scholarly Data Series 2013-5

Table A2: Kilometres of current roads by Italian Province

Italian Provinces	Motorways (km)	Regional roads (km)	Provincial roads (km)	Other roads (km)	All roads (km)	Italian Provinces	Motorways (km)	Regional roads (km)	Provincial roads (km)	Other roads (km)	All roads (km)
Cuneo	119		3300	264	3683	Trapani	124		849	338	1311
Foggia	170	20	2741	638	3569	Piacenza	92		1102	114	1309
Torino	301		2766	157	3224	Reggio-Emilia	40		1125	128	1293
Salerno	193	455	2079	475	3202	Modena	51		1004	206	1260
Perugia	48	777	1958	396	3180	Venezia	107	129	879	126	1242
Roma	332	393	1968	178	2870	Oristano			900	303	1203
Palermo	172	102	1598	753	2624	Mantova	38		827	315	1180
Trento	70		1510	884	2465	Ancona	56		974	139	1170
Lecce			2196	236	2432	Olbia-Tempio			723	427	1150
L'Aquila	131	562	1259	433	2385	Belluno	16	205	709	217	1147
Alessandria	181		2129	0	2310	Pisa	42	203	823	80	1147
Bolzano	116		1234	823	2173	Potenza	65			1072	1137
Frosinone	84	484	1562	33	2162	Ferrara	77		933	97	1107
Pavia	95		1730	333	2158	Isernia				1088	1088
Udine	151	605	1270	109	2135	Vercelli	101		981	0	1083
Messina	197		1423	482	2102	Terni	46	235	657	144	1081
Chieti	89		1786	223	2097	Milano	165		688	216	1069
Sassari			1378	637	2015	Brindisi			927	136	1063
Grosseto		122	1708	156	1986	Ascoli-Piceno	44		959	39	1041
Verona	137	199	1504	137	1978	Ravenna	48		817	162	1028
Teramo	89		1627	259	1975	Vibo-Valentia	36		724	250	1010
Catania	95		1315	501	1911	Savona	105		777	116	998
Avellino	110		1330	466	1906	Imperia	61		788	135	985
Bari	78		1565	251	1893	Novara	103		778	75	957
Brescia	130		1352	370	1852	Pescara	58		791	105	955
Siena	61	206	1477	92	1837	Crotone			826	119	945
Pesaro-Urbino	43		1644	146	1833	Napoli	119	64	542	218	944
Caserta	71		1502	242	1816	Pordenone	32	229	650	32	943
Matera				1764	1764	Fermo	28		856	27	912
Reggio-Calabria	78		1351	249	1679	Cremona	18		631	246	895
Viterbo	29	168	1360	122	1679	Varese	46		605	242	894
Campobasso	36		1254	354	1643	Ragusa		89	638	141	868
Firenze	129	322	1086	100	1637	Massa-Carrara	57	15	643	110	825
Macerata	19		1505	106	1629	Rovigo	25	124	546	82	777
Treviso	100	152	1276	80	1608	La Spezia	64		631	78	773
Catanzaro	47		1280	264	1591	Cosenza	138			627	766
Rieti	29	299	1129	119	1576	Aosta	109	500		153	762
Siracusa	58	122	1056	317	1554	Lucca	67	110	515	69	761
Parma	94		1335	123	1552	Barletta-Andria-Trani	44		584	131	759
Nuoro			864	677	1541	Verbano-Cusio-Ossola	18		538	186	741
Taranto	23		1191	320	1533	Biella			708	6	715
Caltanissetta	14		1147	366	1527	Livorno	34	67	517	96	715
Cagliari			929	562	1490	Como	23		548	97	668
Benevento	11		1270	200	1482	Sondrio			367	238	606
Bologna	172		1134	169	1475	Pistoia	29	87	393	62	571
Vicenza	72	64	1266	47	1449	Rimini	30	48	433	56	566
Agrigento			879	568	1447	Lecco			469	72	541
Arezzo	70	184	1062	126	1441	Lodi	39		449	52	541
Padova	74	167	1093	87	1421	Medio-Campidano			310	178	488
Bergamo	32		1036	326	1394	Carbonia-Iglesias			330	145	475
Asti	45		1312	19	1376	Ogliastra			153	289	442
Enna	66	73	784	450	1373	Gorizia	38	87	128	24	276
Latina		264	938	149	1351	Trieste	30	34	135	30	229
Genova	147		1037	138	1322	Prato	10	4	73	0	87
Forlì-Cesena	43		1075	196	1315	Monza e della Brianza	24			22	46

Source: Own elaboration from ACI (Automobile Club Italia) data, Dotazione di infrastrutture stradali sul territorio italiano, 2011

Appendix B - Robustness checks

Table B1 Estimation results considering only certain Roman roads, EU15 market, σ=8

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel estimates				Cross-section estimates			
Certain Roman roads km (log)	-0.114***	-0.110***	-0.107***		-0.114***	-0.111***	-0.108***	
Certain Roman roads (binary)				-0.102**				-0.103*
Elevation (log)	-0.000	-0.017	-0.026	-0.053	-0.000	-0.017	-0.026	-0.053
Average temperature	-0.018	-0.032**	-0.037*	-0.038*	-0.018	-0.031*	-0.037	-0.038
Coast (binary)	0.020	0.012	0.005	-0.054	0.019	0.012	0.004	-0.054
Austria (binary)	0.066*		-0.105	0.037	0.066		-0.102	0.037
Papal State (binary)	-0.036		-0.071	-0.018	-0.036		-0.072	-0.019
Savoy (binary	-0.035		0.334**	-0.078	-0.034		0.335*	-0.088
Spain (binary)	-0.040		-0.281	-0.124	-0.039		-0.279	-0.117
Venice (binary)	-0.048		-0.152	-0.155	-0.047		-0.150	-0.156
Normans (years)		-0.005***	-0.005***	-0.004***		-0.005***	-0.005***	-0.004**
Swabians (years)		0.001**	0.001*	-0.000		0.001*	0.001	-0.000
Anjou (years)		-0.001	-0.001***	-0.001		-0.001	-0.001**	-0.001
Spain (years)		-0.000	0.001***	-0.000		-0.000	0.001***	-0.000
Bourbons (years)		0.006***	0.005**	0.011***		0.006**	0.005*	0.011***
Papal State (years)		0.000	0.000	0.000		0.000	0.000	0.000
Venice (years)		-0.000	-0.000	-0.000		-0.000	-0.000	-0.000
Austria (years)		0.000	0.000	-0.000		0.000	0.000	-0.000
Savoy (years)		-0.000	-0.001***	-0.001*		-0.000	-0.001**	-0.001
Constant	1.655***	2.145***	2.537***	2.077***	1.616***	1.610***	1.763***	2.167***
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	-	-	-	-
Dummy north/south	YES	YES	YES	YES	YES	YES	YES	YES
Observations	664	664	664	820	83	83	83	103
R-squared	0.798	0.816	0.827	0.723	0.812	0.831	0.842	0.736

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table B2 Estimation results considering only certain Roman roads, world market, σ=11

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)
	Panel estimates			
Certain Roman roads km (log)	-0.093***	-0.082***	-0.077***	
Certain Roman roads (binary)				-0.110**
Elevation (log)	-0.039	-0.067**	-0.086**	-0.075**
Average temperature	-0.034	-0.058***	-0.062***	-0.046**
Coast (binary)	0.033	0.052	0.020	-0.034
Austria (binary)	0.063		0.159	0.294
Papal State (binary)	-0.126*		-0.184**	-0.053
Savoy (binary	-0.107		0.650***	0.308
Spain (binary)	-0.070		-0.028	0.107
Venice (binary)	-0.127		0.004	0.055
Normans (years)		-0.009***	-0.009***	-0.007***
Swabians (years)		0.000	0.000	-0.001
Anjou (years)		-0.000	-0.000	-0.000
Spain (years)		-0.000	0.000***	-0.000
Bourbons (years)		0.009***	0.009***	0.011***
Papal State (years)		0.000	0.000	0.000
Venice (years)		-0.001***	-0.001***	-0.001**
Austria (years)		-0.000	-0.000	-0.001*
Savoy (years)		-0.001*	-0.002***	-0.001***
Constant	2.947***	3.573***	3.691***	2.918***
Regional fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Dummy north/south	YES	YES	YES	YES
Observations	664	664	664	820
R-squared	0.731	0.781	0.802	0.741

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.

Table B3 Estimation results with Instrumental Variables (IV) approach (cross-section data, one instrument)

Dependent variable: Average trade costs (log)	(1)	(2)	(3)	(4)	(5)	(6)
Total current roads km (log)	-0.514***	-0.423***	-0.302***			
Motorways (log)				-0.264***	-0.232***	-0.112**
Elevation (log)	-0.065	-0.094**	-0.054*	-0.090**	-0.097**	-0.097***
Average temperature	-0.067***	-0.079***	-0.057***	-0.047**	-0.052**	-0.055***
Coast (binary)	-0.060	-0.104	-0.003	-0.052	-0.073	-0.049
Normans (years)	-0.019***	-0.021***	-0.013***	-0.035***	0.004	-0.025***
Swabians (years)	0.001	0.001	0.001	0.001	0.000	0.000
Anjou (years)	0.003***	0.003***	0.002*	-0.000	-0.000	-0.000
Spain (years)	0.000	-0.000	-0.000	0.000	-0.000	-0.000
Bourbons (years)	0.018***	0.020***	0.015***	0.054***	0.063***	0.041***
Papal State (years)	-0.000	0.000	0.000	0.001***	0.001***	0.001***
Venice (years)	0.000	-0.000	-0.000	0.000	-0.000	-0.000
Austria (years)	-0.001**	-0.001**	-0.001*	0.000	0.000	0.000
Savoy (years)	-0.000	-0.002***	-0.001	-0.000	-0.001	-0.000*
Constant	8.294***	8.368***	6.279***	4.798***	0.631	4.322***
Regional fixed effects	YES	YES	YES	YES	YES	YES
Dummy north/south	YES	YES	YES	YES	YES	YES
Observations	83	76	101	72	66	81
R-squared	0.707	0.757	0.721	0.830	0.841	0.791
First-stage instrument coefficient	0.190***	0.217***	0.365***	0.430***	0.458***	0.590***
First-stage F-statistics	13.830	16.600	12.610	17.790	15.530	26.780
Durbin-Wu-Hausman P-value	0.003	0.033	0.028	0.326	0.777	0.118
Cragg-Donald Wald F-statisics	17.810	16.599	12.608	17.787	15.529	26.777
Pagan-Hall P-value	0.981	0.877	0.975	0.700	0.447	0.801
Instrument	Certain Roman roads	Certain & major Roman roads	All Roman roads	Certain Roman roads	Certain & major Roman roads	Major Roman roads

Note: Asterisks denote significance levels; * p<0.10, ** p<0.05 and *** p<0.01.