Appendix A

Alternative metrics for the dependent variable.

In this section, we assess the validity of the results obtained in Table 2 and Table 3 (main text) by performing a set of robustness tests. In particular, we replicate our baseline estimates after substituting the dependent variable according to two different criteria.

First, we focus on the possibility that ascribing patents to each region according to inventor address might lead to misleading results. Indeed, the presence of a specific motorway may increase the patent activity in a specific region i even if some inventors live outside it, so that the real impact of the motorway is to favor inventors commuting. In order to analyze this issue, we built an alternative innovation measure based on applicant address (instead of inventor address). In fact, the inventor plays a central role in conceiving the invention and contributes to its industrialization process; he might have entered into a contract with the applicant (usually the organization for which he-she works) so that the applicant assumes the rights to deal with the invention.

TABLE A1 AROUND HERE

In this case, the use of patents fractional count computed on the basis of applicant address takes into account the existence of inventors working in regions other than their home region. Estimates are shown in Table A.1 and confirm the positive relationship of innovative capacity with the provision of motorways infrastructure at regional level. The estimated coefficients of

$lnMotorways_{i,83}$ are quite larger than those reported in Table 2 and Table 3. It is worth noting that the coefficients of the spatial lag are significantly negative, thus possibly denoting the existence of some displacement effects.

Second, we replicate our baseline analysis using an unweighted patent fractional count as dependent variable, in order to account for the raw quantitative measure of innovative activity at regional level. Comfortingly, our previous results are broadly confirmed, as shown in Table A.2, even if, in this specification, the coefficient of $lnMotorways_{i,83}$ shows values that are smaller in magnitude with respect to those shown in Table 2 and Table 3 in the main text. Notice that in this case results relative to the coefficients of $SpatialMotorways_{i,83}$ show mixed evidence and are not conclusive.

TABLE A2 AROUND HERE

Patents Technology Classes.

Equations (1) and (2), in the main text, assumes that the analysis is conducted at an aggregate level, i.e. considering the sum of the patents originating in a given region, independently from patents sector or technology field. In order to account for possible unobserved heterogeneity associated to different patents technology sectors, we analyze the relation between the highways stock and weighted patent fractional count in each region i, as of 1988, in technological sector s. This more detailed analysis considers patents classified at a more disaggregated level according to their technology class, as in the following Equations, which include also technology class fixed effects, μ_s:

$$lnInnov_{i,s,88} = \alpha + \beta(lnMotorways_{i,83}) + \gamma(lnInnov_{i,s,83}) + \varphi X_{i,s} + \mu_s + \upsilon_{i,s}, \qquad (A.\ 1)$$

$$lnInnov_{i,s,88} = \alpha + \beta(lnMotorways_{i,83}) + \gamma(lnInnov_{i,s,83}) + \theta SpatialMotorways_{i,83} + \varphi X_{i,s} + \mu_s + \upsilon_{i,s}, \qquad (A.\ 2)$$

where $Innov_{i,s,88}$ refers to the natural logarithm of our innovation measure in region i for patents in technological sector s as of 1988. In particular, we consider five different technological classes, built on the basis of the WIPO systematic technology classification, namely Electrical Engineering, Instruments, Chemistry, Mechanical Engineering and Others (residual categories).[1]

In Table A.3 we report results obtained after replicating the analysis on observation units defined at region and technological sector level. Estimated models include also technological sector fixed effects and a specific control for the number of inventors in each sector.[2] Results shown in Table A.3 confirm our previous findings, even if parameter estimates are slightly smaller; moreover, the coefficients of the spatial lag variable are significantly negative in columns (5) and (6).

In Table A.4 in turn we report empirical results of separate regressions for each of the five large technology sectors, both with and without the spatial lag of the highways network. While the coefficient of the highways network is generally positive, it is statistically significant only in the case of the mechanical engineering and instrument category.

TABLE A3 AROUND HERE

TABLE A4 AROUND HERE

Heterogeneity Analysis.

Following Agrawal et al. (2017), we investigate potential heterogeneity associated to differentials in inventors density across regions. Indeed, geographical proximity favors the development of knowledge flows, learning processes and relations among inventors, which in turn might affect innovative performance. In this context, the motorways system may represent an important tool in favoring the creation of networks between scientists and organizations. In order to capture the degree of inventors dispersion over the regional area, we construct a measure of inventor density, ($Inventors_{i,83}/Surface_i$), and we split the sample in High-Density or Low-Density regions, depending on whether they are above or below the mean value of our density measure. We argue that the provision of highways would benefits relatively more those regions where interactions among inventors or researchers require larger travelling distances. In Table A.5 we report results obtained by estimating Equation (1) and (2) after splitting the sample according to regional inventors density (low or high). Results are consistent with those obtained by (Agrawal et al., 2017) and for Low-Density regions show that a 10% increase in motorways endowment leads to an increase in patent fractional count that ranges from 2.6% (column (1)) to 5.5% (column (2)). On the contrary, since the coefficient of $lnMotorways_{i,83}$ is not statistically significant in column (3) and the F statistic in column (4) assumes a very low value, we interpret these results as suggestive of a null impact of motorways in High-Density regions.

TABLE A5 AROUND HERE

Socio-Economic Controls.

Although we are aware that other socio-economic characteristics might not be completely independent from the innovative activity of each region (because they can act as mediating factors) we replicate our main analysis after including some socioeconomic controls. In particular, we add two binary variables for the presence of at least one airport and at least one university headquarters in each region in 1983, and the regional gross value added (per employed) as a proxy for labor productivity. Once again, as shown in Table A.6, comfortingly, all results are broadly confirmed.

TABLE A6 AROUND HERE

Additional Robustness Analysis.

In this section we present results from additional robustness analysis associated to possible threats to identification.[3] In particular, Table A.7 shows IV estimates of Equation 1 (columns (1) to (3)), and Equation 2 (columns (4) to (6)), obtained without including the lagged dependent variable in the control set. The coefficient of $lnMotorways_{i,83}$ is positive and significant across all specifications, being very similar to those reported in Table 3, thus confirming the impact of the 1983 highways on regional innovation activity in the late 1980s.[4]

TABLE A7 AROUND HERE

In Table A.8 we report estimates of Equation 1 (columns (1) to (3)), and Equation 2 (columns (4) to (6)), extended in order to include a measure of social capital, i.e. the turnout in the referendum on divorce in 1974 (Nannicini et al., 2013).[5] Comfortingly, all results are confirmed: the coefficients of $lnMotorways_{i,83}$ are positive and statistically significant and show a magnitude similar to those shown in Table 3 in the main text.[6]

TABLE A8 AROUND HERE

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[1] The database is obtained by classifying patent fractional count according to technological classes. It is worth noting that not all regions in 1988 patented in all sectors.

[2] As a consequence, innovation control variables include both the total number of inventors in each region and the number of inventors in each region in the specific sector *s*.

[3] See paragraph *Other Threats to Identification Strategy* in Section 5.

[4] OLS estimates also confirm findings presented in the main text (Table 2). Results are available upon request.

[5] Data available at: https://www.tommasonannicini.eu/en/works/measures-social-capital-italian-provinces-and-muni/

[6] OLS estimates are also confirmed. Results are available upon request.