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FULL ARTICLE

Urban crisis vs. urban success in the era of 4.0 technologies: Baumol's model revisited

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Abstract

The advent of 4.0 technologies allows a footloose location for firms and people, apparently suggesting a "flat world." In this perspective, cities lose their attractiveness and undergo an urban decline. The aim of this paper is to reflect on urban growth opportunities provided by 4.0 technologies, detaching the analysis from a narrative and speculative explanation. The paper revisits the well-known Baumol model on urban crisis, and all its criticisms and refinements, introducing the adoption of digital technologies in the theoretical reasoning. Expectations arise in favour of a re-launch of urban economies in a spatial income distribution setting. An econometric analysis on Italian provinces proves the validity of the expectations.

KEYWORDS

European regions, labour productivity growth, service sector, urban crisis

JEL CLASSIFICATION

R10, R58, 025

1 | INTRODUCTION

For at least one hundred years, the crucial role of cities has been continuously restated, but also continuously forecasted to come to an end. “Diffusing” technologies (like the telegraph, the car, Internet)—allowing a radical abatement of transport and communication costs and the parallel widening of the commuting control area inside that amazing anthropological constant given by the average travel time of one hour (Marchetti, 1994) —allowed the relaunch of prophesies of urban decline and homogenous distribution of activities in space, the most recent one the forecast of a “death of distance” (Cairncross, 2001). Every time, empirical evidence contradicted and even overthrew these expectations, its logical basis being the advantage of enlarging cities' spatial control and the selection processes pushing top functions in high need of agglomeration economies to choose urban locations.

The advent of the 4.0 technologies is upsetting once again the likely spatial trends of economic activities. In fact, it has radically changed the way people live, work, entertain themselves and do business. The digitalization of society and the economy has drastically transformed the way goods and services are supplied, opening up the possibility of online transactions at levels that only ten years ago could not even have been thought to be possible ways of living and doing business (Capello & Lenzi, 2021).

The COVID-19 pandemic has brought an acceleration towards the digital service economy, forcing society to increase the rate of digital adoption and imposing the implementation of online activities for the sake of health security. The fully-fledged stay at home measures that characterized 2020 and 2021 have generated a futuristic vision of the abandonment of large cities, and large movements to remote locations. The forced experiment of online employment, shopping, workplace, and residence choice due to the lockdown and the fear instilled by the pandemic pulled citizens apart and caused people to avoid crowded spaces at least for a certain period after the pandemic (Florida et al., 2021; Mariotti, 2021). Remote locations accessible through digital connections did not suffer from lack of accessibility to high quality urban services and quality jobs. Suburbanization trends have been documented in the UK and the US (Barns, 2022; Gokan et al., 2022; Liu & Su, 2021). As a result, a revisited “death of distance” (Cairncross, 2001) approach has come to the fore, creating a debate around a sustainable future for cities strongly criticized for the high location costs and the large environmental, social and economic scale diseconomies, relaunching the idea of a “flat world” (Friedman, 2004).

However, 4.0 technologies can also be interpreted as centripetal forces, thanks to their capacity to reinforce urban efficiency and overcome diseconomies of large-scale agglomeration. In fact, the adoption of 4.0 technologies can relaunch productivity and efficiency in goods and services production, overcoming the limits to urban growth foreseen by Baumol's urban disease (Baumol, 1967) as the result of the low possibility of productivity increases in consumer services—the typical urban production (Eckert et al., 2020). The “smart city” intended as the development of advanced and highly efficient digital applications for managing all sorts of urban services, from public transport to health services, has been studied as the way to contain the negative externalities of large cities like traffic congestion and pollution (Caragliu et al., 2011). The new digital technologies require complex knowledge and advanced skills for their adoption, typically concentrated in the largest cities (Eckert et al., 2020); as it is usually the case for complex techno-economic paradigms, new technologies generate higher benefits in advanced areas, through the increase of their efficiency and attractiveness (Duranton & Puga, 2020), possibly overcoming the decreasing returns afflicting bigger cities.

4.0 technologies create therefore at the same time a centrifugal and a centripetal effect. However, no explicit empirical test exists about which forces actually prevail, with most of recent literature being focused in documenting the dispersion ones (see among others Althoff et al., 2021). If centripetal forces are due to prevail, cities are deemed to decline to a steady state with a zero-growth rate, as pointed out by Baumol (1967). If the latter prevails, instead, cities become more attractive, overcome their diseconomies of agglomeration, and keep growing at higher rates than the non-city (small cities and rural areas).[1]

[1]An interesting summary of possible future trends for cities is presented in Kunzmann (2020).

This paper aims to conceptually reflect on new growth opportunities for cities, provided by 4.0 technologies, departing from a narrative and speculative approach, and making use of a theory-based approach and its empirical validation. A way to proceed in this direction is to revisit the Baumol's model (Baumol, 1967), its criticisms and, especially, its version with a dichotomous urban–rural space while putting a renewed emphasis on spatial income distribution rather than on pure production (Aydalot & Camagni, 1986; Behrens et al., 2021; Brueckner & Sayantani, 2022; Camagni & Capello, 2020) (Section 2) and introducing the adoption of 4.0 technologies (Section 3). On conceptual grounds, despite the possible spatial dispersion of service activities generated by 4.0 technologies, urban growth is expected to take place, since the city still prevails over the non-city in both a production and distribution sense, namely through favourable exchange prices (terms-of-trade). Based on an original database on the recent adoption of 4.0 technologies in different economic sectors and territorial environments (NUTS 3 regions) (Section 4), this expectation is econometrically proved in the case of Italian cities (Section 5). Reflections on the future of cities (Section 6) and some concluding remarks end the paper (Section 7).

2 | BAUMOL'S MODEL AND ITS CRITICS

2.1 | The original Baumol model and its criticisms

More than 50 years ago, Baumol published his famous paper "Macroeconomics of unbalanced growth: The anatomy of urban crisis," where he elegantly elaborated an explanation for the urban crisis of large cities during that time. In the logic of Baumol's model, the destiny of an urban zero-growth is explained by the non-progressive nature of services, for which the increases in productivity are eroded by the increases in labour costs.

Starting from the assumptions of an isolated space (the city), whose macroeconomic structure is characterized by two sectors, a "progressive" (manufacturing) and a "non-progressive" (final services) sector, with the same wage levels, the logic of the entire analysis is rather simple and intuitive. If productivity per work hour increases in manufacturing, wages increase too. While in the manufacturing sector this increase is offset by productivity increases, rising wages in the non-progressive sector translate into increases in production costs and prices (Table 1, column(1)).

Over time, labour moves out from the progressive into the non-progressive sector, in consequence of the persistent demand for services. In the long run, the non-progressive sector is destined to absorb all workers from the progressive one, with the latter being able to produce for the increasing demand with a constantly decreasing labour share. Under the assumption of a constant total employment in the city, the aggregate productivity growth and the total product would therefore grow at the rate of the service sector, that is, at a zero rate. The city reaches a steady state, defined by Baumol as the urban crisis.

The conclusions of Baumol's model were soon criticized along two main lines. Most criticisms refer to the assumption of constant productivity growth in services, considered as misplaced for different reasons. First, services are of very different nature. The complementarity between manufacturing and intermediate services—like business services, characterized by a positive (even if lower than in manufacturing) growth of total factor productivity—explains why a shift of the labour force towards these services will be accompanied by a higher increase of aggregate productivity. In fact, even if productivity is assumed to be low in the business sector, a shift of resources into this sector will lead to an increase of its output and of that of the manufacturing sector. The result is a rise, and not a fall, of the aggregate outcome (Oulton, 2001), a result still debated at empirical level (Fernandez & Palazuelos, 2012; Hartwig & Krämer, 2019; Oulton, 2016).

Second, services do innovate, leading to higher productivity. The early explicit efforts to understand patterns of innovation in services emerge in the 1980s in the works by Barras (1986) and Soete and Miozzo (1989). Barras's Reverse Product Cycle models (Barras, 1986) falls within this stream of research, and it concerns the application of ICT to financial services, leading to process innovation, followed by product innovation. Taxonomies of sectors based

TABLE 1 Assumptions and results by theories and approaches.

Theories and approaches Hypotheses/Results	Baumol	Criticisms of Baumol	Aydalot and Camagni	A new criticism of Baumol: the 4.0 vision	Aydalot and Camagni revisited: a 4.0 counter-vision
Sectors	2 sectors: 1. manufacturing, 2. services	2 sectors: 1. manufacturing, 2. services	2 sectors: 1. manufacturing, 2. services	2 sectors: 1. manufacturing, 2. services	4 sectors: 1. manufacturing, 2. progressive standardized services 3. progressive customized services 4. non-progressive services
Space	Single urban space	Single homogeneous space	Dichotomous space: city vs. non-city	Dichotomous space: city vs. non-city, homogenous in terms of location advantages	Dichotomous space: city vs. non-city
Hypothesis	$W/L_1 = W/L_2$ $\Delta Prod_1 > 0$ $\Delta Prod_2 = 0$ Growing specialization in services	$\Delta Prod_2 > 0$	$W/L_1 = W/L_2$ $\Delta Prod_1 > 0$ $\Delta Prod_2 = 0$ Spatial specialization: a. complete → monopoly b. incomplete → weakening monopoly Spatial complementarity: a. complete → "tyranny of the city" b. incomplete → "partial revenge of the non-city"	$\Delta Prod_2 > 0$ Both sectors are footloose	$\Delta Prod_3 > \Delta Prod_1 > \Delta Prod_2$ $\Delta Prod_4 = 0$ No spatial bias for sectors 2 and 4 Spatial bias for sectors 1 (non-city) and 3 (city)
Outcome	Urban crisis	Growth $\Delta Prod_{tot} = \Delta Prod_1 * L_1/L + \Delta Prod_2 * L_2/L$ Δ productivity overlooked by statistics	Unbalanced growth $\Delta Prod_{tot} = \Delta Prod_1 * L_1/L$ Medium term: a. city invades space and exploits non-city b. non-city partially produces services Long term: $\Delta Prod_{tot} \rightarrow 0$	Growth Discovery of the "death of distance" once again The city has no locational advantage anymore	Unbalanced growth $\Delta Prod_{tot} = \Delta Prod_2 * L_2/L + \Delta Prod_3 * L_3/L + \Delta Prod_4 * L_4/L$ A growing sector 3 reproduces again disequilibrium in income distribution "Non-city dependency" rather than "urban tyranny"

on the kind of innovation adopted are developed by Pavitt (1984) and Soete and Miozzo (1989). Another field of work is the one specifying the difference between innovation in services and innovation in manufacturing, based on non-technological aspects (Tether, 2015).

Third, services are particularly exposed to measurement problems, leading to the risk of overlooking productivity increases in official statistics (Aghion et al., 2019; Camagni et al., 2022; Djellal et al., 2013; Griliches, 1992). Some studies point to the difficulty in measuring productivity in services, compared with the manufacturing case (Djellal et al., 2013; Griliches, 1992). These issues refer to the intangible nature of the unit of output; difficulties in identifying the "product," which is always different, tailored to specific needs; quality change that is possibly more difficult to detect in services and to account for in price structures; absence of a market price, typical of public services.

By removing the assumption of the non-progressive nature of urban services, as these criticisms do, the source of urban decline disappears, and the macroeconomic outcome turns out to be the weighted sum of the productivity growth of the manufacturing and the service sectors (Table 1, column (2)).

2.2 | The spatial version of the Baumol model: the monopoly of the city over the non-city

In the literature, a different kind of criticism has been made of Baumol's model, related to the limitations of a one-space model rather than to the non-progressive nature of services. By removing the idea of the city as a unique macroeconomic system, and instead assuming the existence of a dichotomous space, the "city" and the "non-city" (small cities and rural areas), in 1986 Aydalot and Camagni were able to overcome the urban crisis through a spatial income re-distributive effect (Table 1, column (3)).

In the first version of the model, each space is fully specialized and labour is mobile among the two. The city is specialized in non-progressive services, typical intermediate services, while the non-city is specialized in progressive manufacturing (producing the final goods). The assumption of equal wage growth of the two sectors, as in Baumol, is retained. The increase in productivity in the progressive sector generates an increase in wages and an increase in the demand for intermediate services. Under the assumption of perfect labour mobility, the first consequence is the increase in urban labour in the service sector, and therefore the growth of urban physical size, invading the non-city. The increase in service supply is accompanied inevitably by an increase in production costs due to the non-progressive nature of the service sector (Table 1, column (3)).

In this approach, using a simplified two-sector input–output table, the city trades its service output with the industrial goods produced by the non-city. The city's monopoly position in the production of intermediate services allows urban services to be sold at favourable terms of trade to the non-city. In this way, the city transfers the increase in unit costs on the relative prices, and makes the non-city pay for its non-progressive production. The crisis of the city is thus avoided through a redistribution mechanism which penalizes the non-city, giving rise to an unbalanced growth. The non-city becomes a victim of what Aydalot and Camagni call, together with some historians (Braudel, Roncayolo), the "tyranny of the city"; the city grows through redistributive rather than productive mechanisms.

The second version of the model adopts partial specialization of the two spaces, that is, an initial production of the services in the non-city, and no labour mobility. Therefore, both spaces maintain a constant size in terms of employment and population. However, the main result does not change: the city grows through redistributive effects even if to a more limited extent. The non-city, in fact, limits the monopoly of the city, thanks to its partial production of the necessary services.

In the very long run, the consequences of Baumol's model hold: all employment would move to the service sector and the aggregate productivity and output growth converges towards the growth rate of the service sector, namely, zero. However, before this condition is reached, the city exploits its advantage in relative prices and the non-city increasingly produces the necessary services, receiving some advantage, however limited by its likely inferior productivity level in the production of services.

3 | THE 4.0 VISION

3.1 | A new criticism of Baumol: the 4.0 vision

Radical and complex transformations are taking place in modern economies because of the exponential evolution and global adoption of the new technologies, such as artificial intelligence, smart automation, cloud technologies and the Internet of things just to quote some of them. A new technological era has begun, and drastic structural changes are under way in businesses and society.

As mentioned in the introductory section, how these structural changes will transform our economies and societies is very much debated. Optimism about the growth and productivity potential offered by 4.0 technologies diffusion is widespread even if the risks of possible social threats cannot be ignored and are increasingly highlighted (Brynjolfsson & McAfee, 2014; Burlina & Montresor, 2022; Capestro et al., 2022; Frey & Osborne, 2017; McAfee & Brynjolfsson, 2017; Rullani & Rullani, 2018; Schwab, 2017).

Two main transformations are taking place. The first transformation, known as Industry 4.0, is in the field of manufacturing activities, and has received great attention in the literature (Acemoglu & Restrepo, 2020; Büchi et al., 2020). Industry 4.0, in fact, enriches value chains and the exchange of inputs with business partners, supplier and customers (Lasi et al., 2014). The integration of physical objects in the information network represents a deep revolution in the traditional industry and pushes towards a paradigm shift in production processes and business models, setting a new level of development and management for organizations (Ciffolilli & Muscio, 2018; Paiva Santos et al., 2018). The second transformation is identified in the digital service economy, an economy encompassing a sprawling range of businesses, enabled by digital platforms, redesigning the boundaries of products towards services, with the latter increasingly, *substituting* the former (Capello, Lenzi, & Panzera, 2022).

These transformations inevitably affect the conceptual reasoning on the possible trends of cities, and a "4.0 vision" of the above-mentioned criticism of Baumol's model (Table 1, column (2)) can be re-formulated. In a two-sector (manufacturing and services), and two-space (city and non-city) model, the adoption of 4.0 technologies allows us to assume that both sectors are progressive (Table 1, column (4)). The adoption of digital and automation technologies, in fact, makes not only knowledge intensive business services (KIBS) (subsection 2.2), but also services like retail and those related to entertainment (TV services, concerts, football matches, etc.) easily absorb cost increases with productivity increases and enlarge markets. Moreover, the nature of the new 4.0 technologies redesign the boundaries of products towards services and increase the possibility to trade dematerialized goods (e.g., a song, rather than a cd) and services (Capello, Lenzi, & Panzera, 2022). Both sectors become footloose, and services are produced and consumed everywhere, even in non-city areas. This condition leads once again to the speculative idea of the "death of distance."

Under such assumptions, the conceptual framework of Aydalot and Camagni changes. The city competes with the non-city: services can in fact be consumed and produced everywhere at decreasing prices. In these circumstances, the monopoly power of the city over the non-city vanishes. The widespread diffusion of the progressive sector leads finally to a balanced growth.

This line of reasoning would give support to the idea that the city loses its attractiveness in comparison with the non-city, as its agglomeration economies are perfectly balanced out by rent costs.

3.2 | A 4.0 counter vision

The reality is instead more complex than the one explained in the simple 4.0 vision, and despite the widespread adoption of 4.0 technologies, the city (and especially the large city) can still show some sort of control over the non-city. However, to be justified, this impression requires a theoretical elaboration. To achieve such an aim, the previous approaches are here revisited in a "4.0 counter vision", adopting once again a dichotomous space.

First, let us assume that the economy comprises four specific sectors. The first sector is the manufacturing sector, which is, as in all other reasoning from Baumol onward, a progressive sector. This hypothesis is even reinforced in the 4.0 technological era, where industry can take advantage of digital automation as mentioned above. In this case, labour is "an incidental requisite for the attainment of the final product" (Baumol, 1967, p. 416), subject to high substitution with capital for efficiency gain purposes (Table 1, column (5)).

Instead, a more in-depth reasoning has to be applied to the service sector. In particular, the service sector is made of sub-sectors of a different nature, and therefore with a different permeability to new technologies. The distinction between non-progressive and progressive services still holds. Services in which the primary instrument is labour, where labour is "itself the end product" (Baumol, 1967, p. 416), are by definition non-progressive. For their nature, despite the invention of new technologies, there still seem to be precise limits to productivity increases, like in the case of teaching activity.

However, the variety of existing services opens up to different situations where technology affects productivity gains also in services. Two main categories of progressive services can be identified. "Progressive standardized" services are those services achieving higher productivity growth thanks to the achievement of economies of scale obtained through technological advancement. The retail sector is a good example in this respect: with the advent of e-commerce, the opportunity to enlarge the size of the market *online* has drastically increased, leading to labour productivity increases; standardized products/services are sold, potentially, at the global scale, with competition still happening through prices.

Beside the opportunity to achieve scale economies, a different adoption aim characterizes what in this paper are labelled "progressive customized" services. These services make use of the new technologies not only to expand market size by offering the same service to a larger customer base (i.e., economies of scale) but also to achieve higher quality, to exploit economies of scope and to enlarge the size of the market through a horizontal market differentiation. The entertainment sector is an example in this respect. Despite the fact that labour is "itself the end product", a football match can be sold on a much larger market when it is streamed *online*, especially through a pay-tv system. In this case, the productivity of each football player drastically increases for two reasons. The market size expands because the event is streamed online and can reach a wider audience, but also because the customer base can be differentiated according to customer preferences, for example, by following the event on demand. The customized nature of such services and the consequent horizontal market differentiation may lead to a price increase of the new customized products, and therefore to higher productivity measured at current prices. The revenues generated by the football match transmitted by pay-tv, in fact, increase substantially, keeping the number of football players constant.

As rightly underlined by Baumol, the difference in productivity growth by type of activities is a relative concept, and it is a matter of the degree of productivity growth rather than of an absolute dichotomy. A hierarchy of productivity increases can be expected, with the maximum level reached by customized services followed by manufacturing and by standardized services. Lastly, it is reasonable to expect that non-progressive services have very limited productivity increases, something that makes them similar to Baumol's non-progressive services (e.g., hairdressers).

In line with Aydalot and Camagni, space is dichotomous the city vs. the non-city. The city is specialized in progressive customized services since they require a high-quality labour force and advanced knowledge in order to be produced, which are typical urban production factors. The non-city is specialized in manufacturing. The progressive standardized services and the non-progressive services are instead assumed to be present everywhere, given their relative simpler production techniques and lower quality of their production factors.

The way in which the new technologies influence productivity growth differs in the four sectors. The non-progressive sectors follow Baumol's logic: since they are not subject to 4.0 technology adoption, they show very limited productivity gains. However, since non-progressive services are sold in local markets, the increases in prices, due to adjustments of wages, are common in both the city and the non-city market, and not transferred on the spatial terms-of-trade.

As regards the progressive standardized services (e.g., retail, travel agencies), they are sold and produced everywhere, and the 4.0 technologies reinforce such a widespread diffusion. The pervasive diffusion inevitably decreases prices everywhere, and the city competes in terms of prices with the non-city.

Progressive customized services are those able to increase productivity and quality thanks to new technologies. They are sold everywhere but produced only in the city due to the availability of high-quality labour inputs. This situation creates opportunities for the city to increase prices. As the non-city is dependent on the supply of such services, the increases in prices by the city become favourable terms-of-trade. In these types of services, the city exerts its tyranny through the terms-of-trade, and the countryside dependency generates distributive effects in favour of the city.

In this framework, the final conclusion about absolute and relative urban dynamics depends on the relative weight of the three types of services produced by cities. Aggregate productivity growth is in fact the result of the weighted sum of the three types of services present in the city. As long as the progressive customized services have a prevailing weight over the others, the monopoly power of the city is maintained as clearly visible in large cities, and urban growth continues in the conceptual framework of a spatial income distribution (Brueckner & Sayantani, 2022; Camagni, 2020).

All these hypotheses require empirical validation. In particular, there is a need to prove that productivity growth at constant prices (volume of output per worker):

Hypothesis 1. differs in the different sectors;

Hypothesis 2. does not increase in non-progressive services despite the adoption of 4.0 technologies, in both the city and the non-city;

Hypothesis 3. increases in standardized services when 4.0 technologies are adopted, in both the city and the non-city; and

Hypothesis 4. increases when 4.0 technologies are adopted in customized services in cities.

But this is not all. In fact, the adoption of 4.0 technologies may generate changes in quality of goods and services, reflected in price variations, as follows:

Hypothesis 5. a price increase, when 4.0 technologies are adopted in progressive customized services, especially in cities;

Hypothesis 6. price decrease, when 4.0 technologies are adopted in standardized customized services, everywhere; and

Hypothesis 7. a neutral effect on prices from 4.0 technology adoption in non-progressive service sectors.

These expectations will be proved in the empirical part of the paper, which follows.

4 | FROM THEORY TO EMPIRICS

4.1 | Identification of the different groups of sectors

The empirical verification of the set of hypotheses formulated in Section 3 on the realm of Italian provinces (NUTS 3) requires precise conceptual reflections on the logic and the operationalization of both the distinction between the different groups of sectors (presented in this section) and the separation of the city from the non-city (presented in the next section). Italy represents an ideal terrain for the empirical verification, for several reasons. First, as far as urbanization is concerned, it presents highly differentiated territorial settings. Metropolitan and rural areas coexist, across all parts of the country. At the same time, the level of digitalization is highly unbalanced, with a gap between the North and the South of Italy. Finally, as other large countries, also Italian regions are characterized by heterogeneous sectoral mix and specializations.

On conceptual grounds, the distinction between the different groups of sectors depends on two dimensions: the technological intensity of each sector and its productivity level. The technological intensity of a sector accounts for its capacity to exploit modern digital technologies so as to reach higher efficiency, and, therefore, is used to separate progressive from non-progressive services. According to Baumol, in fact, progressive sectors are those in which innovation leads to productivity growth. On the other hand, those services in which labour is a fixed element in the production function, since there are low possibilities to replace workers with technologies, are defined as non-progressive. The productivity level, instead, accounts for the value added produced by each sector and, indirectly, for the technology adoption strategies put in place in the different sectors. By their own nature, customized services are more complex than standardized ones and are characterized by adoption strategies oriented towards the achievement of scope and diversification economies and not only pure scale economies as in standardized services. Accordingly, the productivity level is used to separate customized services from standardized ones. In fact, keeping constant the amount of labour, customized products are expected to embed a higher value added than standardized products. By the very nature of the services offered and traded, customized services may take advantage of horizontal differentiation (customized products) rather than horizontal one (standardized goods). This translates into the possibility of selling at higher prices and, in turn, of obtaining higher revenues and therefore higher value added.

On an empirical ground, the distinction between progressive and non-progressive service sectors follows the OECD division between medium-high vs. medium-low digital intensive sectors (Calvino et al., 2018).[2] Based on this classification, those sectors classified by the OECD as medium-high digital adopters are considered, in our analysis, progressive, while the medium-low adopters are classified as non-progressive. Among the progressive sectors, the distinction between customized vs. standardized services is based on the mean value of their sectoral productivity level with respect to the regional average one; specifically, within the group of progressive sectors, those with a higher-than-average productivity level with respect to the overall regional economy one is classified as customized, while those with a lower-than-average productivity level as standardized.[3]

Table 2 lists the different groups of service sectors and their respective NACE codes (according to NACE2 Rev2 classification).

4.2 | The concept of city and its measurement

The concept of city represents a clear and well-accepted conceptual archetype of an economic system, which has been long studied for having distinctive characteristics:

- in static terms, it generates agglomeration economies, i.e. increasing returns to firms and individuals; and
- in dynamic terms, it is a source of knowledge creation and the main locus of collective learning and innovation processes.

[2]The OECD classification does not include all economic sectors. For this reason, our analysis does not include agriculture, industry other than manufacturing, construction, finance, and public services. Among the sectors covered by the OECD classification, telecommunication (J61) is excluded from the present analysis, since prices are strongly regulated.

[3]The sectoral productivity level is measured in 2013 at the national level. Data has been sourced from ISTAT.

TABLE 2 Customized, standardized and non-progressive services.

Progressive customized services	
Motion picture, video and television programme production, sound recording and music publishing activities (J59)	
Professional, scientific and technical activities, except veterinary activities (M69 to M74)	
Progressive standardized services	
Administrative and support service activities (N77-N82)	
Information service activities (J62-J63)	
Publishing, audio-visual and broadcasting (J58-J60)	
Wholesale and retail trade, repair (G45-G47)	
Non-progressive services	
Transportation and storage (H49-H53)	
Accommodation and food service activities (I55-I56)	
Real estate (L69-L71)	

The co-presence of these two characteristics clearly identifies the city economic archetype and its self-evident distinction from the non-city.

This conceptual clarity clashes, however, with the empirical difficulties in measuring the city and in identifying its spatial boundaries, that is, when and where a city ends and a non-city starts.

The literature is very rich in alternative measures aimed at solving this puzzle. The first option is to follow the administrative approach and to use the NUTS classification to identify cities. There is a solid tradition supporting this approach and using specifically NUTS3 regions to measure cities not only in the scientific literature (see among others e.g., Ciccone, 2002; Di Liberto & Sideri, 2015; Guiso et al., 2004; Perucca, 2014) but also in the official statistics and policy field, with EUROSTAT producing a classification of metropolitan areas based on NUTS3 regions.[4] The alternative option is to follow a functional approach, based on the identification of functional urban areas (FUA).

We choose to follow the administrative approach and use NUTS3 regions as a measure of cities for multiple reasons. First, NUTS3 regions are a good base to capture agglomeration economies (Camagni et al., 2021; Capello, Caragliu, & Gerritse, 2022). Moreover, the classification of NUTS3 regions remains constant over our period of analysis. Second, the list of FUAs proposed by ISTAT has a close resemblance to the local labour system (LLS), a small spatial unit to cover large cities and to capture the operation of urbanization economies. In fact, Milan NUTS3 contains five LLSs, Rome contains seven LLSs, Turin contains eight LLSs. On the other hand, the list of FUAs proposed by EUROSTAT overlaps almost perfectly with NUTS3 regions, with a few exceptions of FUAs made up of multiple NUTS3 areas (for a detailed discussion on this see Camagni et al., 2021). Finally, ISTAT produces a list of 83 FUAs, which gets very close to the 106 NUTS3 regions analysed in our work. This similarity, and the advantages of using NUTS3 regions in terms of data collection for the other variables used in the econometric analysis made us conclude that using NUTS3 regions as a measure of cities is the best approach in our case. Specifically, cities are identified as the 10% largest NUTS3 regions, a threshold corresponding to a population of 1 million inhabitants.[5]

[4]https://ec.europa.eu/eurostat/web/metropolitan-regions/background.

[5]Our findings are consistent also considering the 20% largest NUTS 3 regions. Results on this are available from the authors upon request.

4.3 | Measuring changes in labour productivity and prices

In order to proceed in our empirical analysis, we need a measurement of labour productivity growth and price changes, both expected to be highly differentiated across sectors and territorial settings (i.e., city vs. non-city). These measurements will be applied to a database on the 106 Italian NUTS3 regions in the period 2014–2019.[6]

Relative regional sectoral labour productivity growth (w.r.t. the overall regional one) is defined following the traditional VA per worker measurement and its change as follows:

$$\Delta \textit{Relative labour productivity}_{r,s} = \left(\Delta \frac{VA_{r,s}}{Employment_{r,s}}\right) - \left(\Delta \frac{VA_r}{Employment_r}\right), \quad (1)$$

where *VA* stands for value added at constant prices (base year 2014), r is the region ($r = 1, \ldots,106$), s ($s = 1, \ldots,4$) the group of sectors and Δ indicates the absolute variation between 2014 and 2019. The use of sector-specific deflators allows for a more careful measurement of the change in labour productivity of each sector.

Value added and employment are measured using ISTAT data. Since ISTAT provides, for NUTS3 regions, data on value added and employment with a sectoral breakdown not fully consistent with our classification (Table 2), we calculated a set of regional weights in order to disaggregate ISTAT data at a finer sectoral level. These weights have been estimated using AIDA–Bureau Van Dijk database.[7]

A more complex methodological aspect accompanies the measurement of the change in relative prices across sectors. We overcome the lack of regional sectoral deflators data by reasoning as in Camagni et al. (2022), in line with Acemoglu et al. (2014). We interpret productivity increases at constant prices as encompassing normal, "business as usual" quality increases in existing products and the sectoral differential increases in prices with respect to the national average inflation rate as the expression of the "quality / monopolistic competitive effect" of new products.[8] The difference between the sectoral increase in prices and the national average inflation rate captures those sectors able to sell their output at increasing prices by exploiting a market power created by novelty/quality/differentiation of products appreciated by customers. If regional sectoral deflators were available, there would be a more precise and direct way to measure the "quality/monopolistic competitive" effect. Given the fact that only national sectoral deflators are available, we can only capture "quality/monopolistic competitive" effect through the presence of a favourable mix of sectors in regions and not through a specific sectoral regional price variation.[9]

In empirical terms, we estimate, for each sector, the difference between the change in labour productivity at sectoral-deflated prices and the change in labour productivity calculated using the overall country deflator. This is illustrated in the following formula:

$$\Delta \textit{Relative price}_{sn} = (\delta_{sn,t1-t0} - \delta_{n,t1-t0}), \quad (2)$$

[6]The selection of the time span balances several arguments. First, we focused on this specific period in order to avoid the potential influence of exogenous shocks that impacted Italian regions with an unbalanced intensity. On the one hand, the 2008 crisis negatively affected regional economies until 2013 (Mazzola & Pizzuto, 2020). On the other hand, the COVID-19 pandemic, significantly influenced regional performance from 2020 onwards. Moreover, taking into consideration implementation lags, earlier technology adoption data would refer to the old waves of computerization and of the ICT revolution and not to the modern technologies. Lastly, in a context like Italy, traditionally known as a laggard country in terms of technology adoption and digitalization, an earlier measurement would not be feasible nor particularly appropriate to grasp the adoption of 4.0 technologies (Capello, Lenzi, & Perucca, 2022).

[7]More specifically, ISTAT provides information on value added and employment at the NUTS 3 level for the sectors G-I, J, L and M-N. Hence, using data from AIDA–Bureau Van Dijk we calculated, for each NUTS 3, the share of value added and employment in the sub-sectors of interest. In this way we were able to disaggregate, for instance, the value added and employment respectively of G, H and I.

[8]In their paper, Acemoglu et al. (2014, p. 397, italics added) claim that "If IT-intensive industries have upgraded their quality relative to other industries and *this is not fully captured by the industry price deflators*, this mismeasurement could explain the decline in real shipments,"

[9]Given the unavailability of regional sectoral deflators, if in a region the sectoral mix were equal to the national one, then the aggregate regional Δy^* would be equal to 0.

where the subscript n indicates the national level and δ_n the country-level deflator. Therefore, our indicator of price change defined in Equation (2) is a measure of the capacity of sectors to sell at higher prices than other sectors thanks to higher quality goods/services, and takes a value of 0 when the prices in the sector s have the same variation as national inflation. Positive (negative) values, on the other hand, indicate that the sector is able to sell its output at increasing (decreasing) prices with respect to the national average.[10]

4.4 | Measuring digital technology adoption

The specific measure of digital technology adoption used in this paper is the diffusion of cloud services in Italian firms, namely the share of firms using cloud services in a NUTS3 region. Admittedly, the operationalization of the concept of 4.0 digital technologies can be controversial due to the complexity and multifaceted nature of the phenomenon. The solution adopted in the paper balances several arguments.

The first decision was that of excluding the use of patent data in advanced digital technologies, for example, artificial intelligence, and the use of automation technologies, namely, robot adoption. This choice has strong conceptual roots. Patents represent inventions, the most cutting-edge ones, but they do not necessarily go in tandem with adoption, especially in services which typically rank low in patenting, as remarked in the literature (Tether, 2015). Similarly, robot adoption data mainly covers the manufacturing sector and is generally used as a proxy for the technological transformations taking place in the manufacturing environment, the so-called Industry 4.0 (Acemoglu & Restrepo, 2020; Büchi et al., 2020). However, the paper extends the analysis beyond the Industry 4.0 transformation in order to examine the transformations taking place in both manufacturing and service sectors, making neither of these indicators suitable in the present setting.

Having excluded these two options, data availability dictated important constraints in the choice of the final indicator. The criterion that inspired the final choice was that of selecting an indicator able to capture at least some of the novel aspects of the present digitalization with respect to the past ICT revolution, largely based on the endowment of ICT equipment and/or infrastructure (e.g., ICT equipment and/or personnel, see Calvino et al., 2018; e.g., Autor et al., 2003; Goos et al., 2014). The collection of data on the use of Artificial Intelligence (AI) or big data started quite recently (e.g., EUROSTAT national data on AI starts from 2018 with sizeable gaps), and with a temporal coverage not amenable for the present analysis. Differently, data on the use of cloud services presents a sufficient temporal coverage, compatible with the purpose of the present analysis. Accordingly, the indicator selected for the analysis was one based on the use of cloud services.

We are aware that the use of cloud services captures only a portion of the (many) advanced technologies currently in use; yet, they do still represent an area of major technological advances, being also crucial to the development of the smart fabric and of Internet-of-Things (European Patent Office - EPO, 2020).

Specifically, the indicator chosen is based on firm-level microdata sourced from ISTAT on the use of ICT in Italian companies with at least 10 employees. Yearly data are available for the period 2013–2017 with a fine sectoral and regional (i.e., at the NUTS2 level) breakdown.

Unfortunately, however, data are not available with both a territorial and a sectoral breakdown. To overcome this limitation, we adopted an apportionment strategy to estimate NUTS3 level sectoral data starting from sectoral national data, following an approach similar to the one applied by Capello and Lenzi (2021) in line with the literature (e.g., Acemoglu & Restrepo, 2020). First, we computed the national share of firms adopting cloud services in each of the four groups of sectors described in subsection 4.1 based on the firm-level microdata sourced from ISTAT on the

[10]We are aware that output prices may change also due to reasons other than the market mechanisms, such as for instance a variation in the cost of inputs. The latter, however, is not so important for the service sectors, whose use of intermediate inputs is relatively small. On the other hand, an aggregate manufacturing sector alleviates sectoral input price differences. However, as a guarantee, we analysed the trend in the oil and gas process over the period of analysis: its negative trend guarantees that our "price (quality)" index is not influenced by pervasive energy price increases. Results on this are available upon request.

use of ICT in Italian companies with at least 10 employees. Second, we applied, in turn, a set of two weights accounting respectively for the development of the NUTS 3 sectoral specialization and the digital infrastructure in each NUTS3, both expected to raise the intensity of use of digital technologies.

In detail, the first weight is obtained as the NUTS3 sectoral specialization with respect to the country in each group of sectors following the expectations that regions more specialized in a specific sector contribute more to national cloud services adoption in the same sector, and thus have a greater share of firms adopting cloud services. NUTS3 sectoral specialization has been computed as the location quotient based on employment data sourced from ISTAT.

The second weight is computed as the location quotient, calculated according to the usual formula, of the households with broadband access in 2011 (source: ISTAT Census data), following the expectation that cloud services are more diffused in regions with a more digitalized population, that is, in regions more prone to adopt new technologies.[11]

By this apportionment methodology, it was possible to compute the share of firms adopting cloud services at the NUTS3 level for each group of sectors.

5 | EMPIRICAL ANALYSIS

5.1 | Methodology

The empirical validation of the hypotheses elaborated in Section 3 is based on two sets of analyses. The former focuses on the different productivity behaviour in the four sectors (i.e., non-progressive, manufacturing, progressive standardized, progressive customized) across different urban settings (i.e., city vs. non-city) depending on the intensity of new technology adoption (i.e., the share of firms adopting cloud services). The latter extends this analysis by looking at the evolution of prices.

On econometric grounds, for each set of analyses, two groups of equations have been estimated, summarized in the following equations:

$$\Delta Relative\ labour\ productivity_{r,s} = f\left(4.0\, technologies_{r,s}, city_r, controls_{r,s}\right), \tag{3}$$

where r stands for the NUTS3 region and s for the group of sectors (i.e., non-progressive, manufacturing, progressive standardized, progressive customized). $\Delta productivity_{r,s}$ is computed as defined in Equation (1) above. Each equation applies to specific hypotheses (Section 3). In particular, Equation (3) enables verification of whether productivity growth does differ across the different groups of sectors and whether technology adoption does bring different productivity advantages across sectors.

In order to test whether, for each sector, the impact of technology adoption (i.e., cloud services) varies across different types of settlements (i.e., city vs. non-city), the model specification becomes as follows:

$$\Delta Relative\ labour\ productivity_r = f(4.0\, technology_r, city_r, 4.0\, technology_r * city, controls_r). \tag{4}$$

While the interaction between the adoption of 4.0 technologies and the city dummy is justified on conceptual grounds, as discussed in subsection 3.2, it is worth noting that the empirical association between these two variables further calls for the study of their joint effect on productivity. Table 3 reports the results of an analysis of variance (ANOVA) comparing the share of firms adopting cloud services in different sectors and

[11]It is worth noting that, form an empirical perspective, the two weights (i.e. the specialization of NUTS 3 regions in the four sectors and the share of households with broadband access) have a low correlation, always below 0.5.

TABLE 3 ANOVA results on the share of firms adopting cloud services by sectors and between city vs. non-city.

	Non-city	City	F-test
Share of adopting firms (all sectors)	16.45	20.75	8.2***
Share of adopting firms by sector			
Non-progressive	12.72	14.07	5.64***
Progressive standardized	20.15	25.23	12.84***
Manufacturing	16.54	14.56	0.92
Progressive customized	18.93	29.02	15.3***

Note: *** indicates a p-value lower than 0.01.

between city vs. non-city. The table shows that in all the three service sectors defined in our analysis, the adoption of cloud services is significantly higher in cities. The gap in the average share of adopting firms is particularly high in the case of progressive services (both standardized and customized), while differences are insignificant in the case of manufacturing. This suggests that the interacted effect of urbanization and 4.0 technologies on productivity may occur not just as the result of a higher relative specialization of cities in progressive services but also because, keeping constant the specialization level, sectors located in large urban areas tend to innovate more, possibly exploiting advantages associated to the critical mass of 4.0 technologies' users in cities.

In parallel, sectors do not compete just on productivity gains, but also on the increase in the quality of products, which translates into higher prices. The price (quality) effect is calculated as in Equation (1). This enables verifying whether the different groups of sectors are characterized by different pricing strategies, what is the role of technology adoption in this regard (Equation (5)) and, for each group of sectors, whether the effect of cloud services adoption on quality and prices is different in the city compared with the non-city (Equation (6)):

$$\Delta Relative\ price\ (quality)_{r,s} = f\left(4.0\, technology_{r,s}, city_r, controls_{r,s}\right), \tag{5}$$

$$\Delta Relative\ price\ (quality)_{r} = f(4.0\, technology_{r}, city_r, technology_r * city, controls_{r}). \tag{6}$$

As a control variable, Equations (3) and (4) include the initial sectoral productivity level. Moreover, a set of dummy variables for each NUTS2 region captures the unobserved effects. Variables description and summary statistics are available in Appendix Table A1. Finally, in terms of estimation, all equations have been estimated through ordinary least squares with robust standard errors.[12]

5.2 | Discussion

The results of the estimations are reported in Tables 4–8. Starting with the estimation of Equation (1), results largely support Baumol's conclusion concerning productivity of non-progressive services (Table 4, column (1)) and our first hypothesis (Section 3, Hypothesis (1)). In relative terms, in fact, progressive standardized services and manufacturing enjoy a higher productivity growth, relative to the NUTS3 average, than non-progressive. The coefficient associated to the progressive customized services, although positive, is not statistically significant (p-value $= 0.240$). Adding the initial productivity level, jointly with its interactions with the different sectors (column (2)), suggests that productivity converged, in the period analysed, across sectors.

[12]We tested for the presence of cross-sectional dependence in the same sector across different regions. Results of Pesaran's tests suggest that the data are cross-sectional independent.

Three additional and important messages come from Table 4. First, relative productivity growth is higher in cities in all model specifications (columns from (2) to (5)). Second, relative productivity growth is characterized by increasing returns to technology adoption, the coefficient of the squared term of the adoption variable being positive and significant and the coefficient of the simple term negative and significant (Table 4, columns (3) and (4)). This result reminds us that the network nature of such technologies demands that a critical mass of adopters be achieved at the regional level so as to enjoy the advantages stemming from technology adoption. Third, technology adoption impacts relative productivity growth differently, depending on the sector considered (Table 4, column (5)). In fact, technology adoption seems to benefit relative productivity growth only in standardized and, to a certain extent, customized services, for which the interaction term between the adoption variable and the sectoral dummy variable are significant (with $p < 0.15$ in the case of customized services).[13] On the other hand, technology adoption does not seem to impact relative productivity growth in manufacturing or in non-progressive services. The sectoral heterogeneity highlighted by these results is further explored in Table 5, through the estimation of Equation (4) for each group of sectors, leading to several interesting messages. First, relative productivity growth in non-progressive services is neutral to technology adoption both in the "city" and in the "non-city"; neither variable, in fact has a significant effect, as expected (Table 5, columns (1)–(3)). This is consistent with our Hypothesis (2) (Section 3). More interesting instead is the case of standardized services. In this case, technology adoption is positively associated with relative productivity growth (Table 5, column (4)) confirming our Hypothesis (3). This effect, however, prevails in cities at very high levels of adoption, as shown by the positive and significant effect of the interaction variable between the squared term of adoption variable and the city dummy and by the negative and significant effect of the interaction variable between the simple term of adoption variable and the city dummy (Table 5, column (6)).

Lastly, concerning customized services, relative productivity growth is especially high in cities (Table 5, columns (7)–(9)) and subject to a U-shaped impact of technology adoption (Table 5, column (8)). Surprisingly, instead, the interaction terms of the city dummy with the simple and squared term of the adoption variable are not significant (Table 5, column (9)), partially in contrast with Hypothesis (4). This result may depend on the fact that technology adoption in customized services is particularly high in cities (Table 3), weakening the strength and significance of the interaction term.

Taken together, results from Tables 4 and 5 confirm our expectations on the different patterns of productivity growth across sectors and on the heterogeneity across sectors of the role of technology adoption and of the role of the city.[14]

Tables 6–8 propose interesting results with regard to the relative price (quality) effect. First of all, Table 6 shows a statistically significant difference in the relative price (quality) effect in the four sectors; non-progressive and manufacturing signal a price competitiveness strategy (i.e., negative average values of the relative price (quality) effect), while progressive standardized and customized show increasing price strategy (i.e., positive average values of the relative price (quality) effect), the latter decisively more than the former. This difference is reinforced in cities, where customized services seem abler to sell at increasing prices. These results are confirmed in the estimates in Table 7, columns (1) to (4). Moreover, the relative price (quality) effect is characterized by increasing returns to technology adoption, the coefficient of the squared term of the adoption variable being positive and significant and the coefficient of the simple term negative and significant (Table 7, columns (3) and (4)). Finally, and most importantly, technology adoption has a positive association in the case of progressive services, both customized and standardized (Table 7, column (5)).

Table 8 provides further evidence in this regard, which overall support the conceptual expectations. In detail, and as expected, technology adoption leads to a quality increase in non-progressive and standardized services for low adoption levels, when competition is low. While adoption increases (Hypothesis (6)), competition gets fiercer and in these sectors firms compete through price decreases (Table 8, columns (2) and (5)), as shown by the negative

[13]The significance of the interaction was confirmed by a Wald test on the interacted coefficients.

[14]For the sake of completeness, Table 5 (columns (10)–(12)) reports the same set of estimates in the case of the manufacturing sector. Results do not signal any particularly evident relationship, consistently with the conceptual discussion in Section 3.

TABLE 4 Relative productivity growth: sectors and technology adoption.

Dependent variable: productivity growth relative to the NUTS 3 average	(1)	(2)	(3)	(4)	(5)
Progressive standardized (1)	0.093***	1.721**	1.735**	1.778**	1.394*
	(0.017)	(0.839)	(0.839)	(0.840)	(0.780)
Manufacturing (2)	0.201***	2.067**	2.054**	1.934**	1.802**
	(0.021)	(0.852)	(0.857)	(0.857)	(0.804)
Progressive customized (3)	0.029	2.541***	2.518***	2.533***	2.183**
	(0.026)	(0.910)	(0.920)	(0.919)	(0.853)
Share of firms adopting cloud services			−0.032	−0.585*	−1.315
			(0.130)	(0.309)	(0.818)
Square of the share of firms adopting cloud services				1.072**	
				(0.486)	
City dummy		0.056**	0.058**	0.052**	0.060**
		(0.022)	(0.022)	(0.023)	(0.026)
Share of firms adopting cloud services in progressive standardized services					1.903**
					(0.827)
Share of firms adopting cloud services in the manufacturing sector					1.198
					(0.934)
Share of firms adopting cloud services in progressive customized services					1.175
					(0.811)
Productivity level at time 0		0.206	0.205	0.196	0.174
		(0.176)	(0.176)	(0.176)	(0.168)
Productivity level at time 0 in the manufacturing sector		−0.434**	−0.431**	−0.401**	−0.411**
		(0.187)	(0.189)	(0.189)	(0.193)
Productivity level at time 0 in the progressive standardized sectors		−0.377**	−0.381**	−0.390**	−0.375**
		(0.184)	(0.184)	(0.184)	(0.182)
Productivity level at time 0 in the progressive customized sectors		−0.586***	−0.580***	−0.584***	−0.537***
		(0.200)	(0.203)	(0.203)	(0.199)
Constant	−0.034	−1.007	−0.996	−0.900	−0.686
	(0.056)	(0.799)	(0.800)	(0.793)	(0.730)
NUTS2 dummies	YES	YES	YES	YES	YES
R-squared	0.222	0.340	0.340	0.345	0.350
Observations	424	424	424	424	424

Notes: N = 424.
***p < 0.01, **p < 0.05, *p < 0.1. Robust standard errors in parentheses.

sign of the squared term of the adoption variable. In customized services, instead, the adoption of cloud services is associated with positive pricing effects, especially when the adoption is high (Table 8, columns (7) and (8)), a situation taking place in the city (Table 8, column (9)), consistent with Hypothesis (5).[15]

[15] For the sake of completeness, Table 8 (columns (10)–(12)) reports the same set of estimates in the case of the manufacturing sector. Results highlight a persistent negative pricing effect, suggesting that the adoption of the new technologies has the chief goal of lowering pricing, especially when competition becomes harsher (Table 8, column (11)).

TABLE 5 Relative sectors' productivity growth: the role of the city.

Dependent variable: productivity growth relative to the NUTS 3 average	Progressive customized			Progressive standardized			Non progressive			Manufacturing		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Share of firms adopting cloud services	−0.211	−1.331**	−0.925	0.672**	−2.236	0.603	0.148	−13.091	−20.783	−0.676***	−1.645	−1.345
	(0.269)	(0.636)	(1.002)	(0.306)	(1.885)	(1.687)	(0.793)	(9.719)	(13.287)	(0.245)	(1.372)	(1.484)
Square of the share of firms adopting cloud services		1.758**	0.923		6.341	−0.458		48.695	77.892		2.469	1.766
		(0.881)	(1.844)		(4.275)	(3.816)		(34.633)	(48.513)		(3.290)	(3.516)
City dummy	0.124**	0.109*	0.405*	0.047	0.028	0.733*	0.020	0.021	−2.724	0.032	0.028	0.135
	(0.059)	(0.056)	(0.239)	(0.034)	(0.030)	(0.373)	(0.046)	(0.045)	(1.711)	(0.046)	(0.047)	(0.246)
City dummy x share of firms adopting cloud services			−2.128			−6.378**			38.806			−1.102
			(1.535)			(3.083)			(23.879)			(3.293)
City dummy × square of the share of firms adopting cloud services			2.955			13.848**			−134.675			2.156
			(2.188)			(6.279)			(80.944)			(10.139)
Productivity level at time 0	−0.435***	−0.432***	−0.435***	−0.123	−0.110	−0.098	0.166	0.153	0.149	−0.430***	−0.414**	−0.416**
	(0.113)	(0.114)	(0.118)	(0.105)	(0.099)	(0.106)	(0.182)	(0.175)	(0.178)	(0.160)	(0.163)	(0.163)
Constant	1.741***	1.885***	1.862***	0.337	0.605	0.275	−0.686	0.251	0.762	2.012***	2.038***	2.019***
	(0.449)	(0.457)	(0.458)	(0.402)	(0.454)	(0.466)	(0.804)	(0.778)	(0.869)	(0.644)	(0.650)	(0.633)
NUTS 2dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.459	0.478	0.485	0.322	0.363	0.398	0.232	0.248	0.259	0.492	0.495	0.498
Observations	106	106	106	106	106	106	106	106	106	106	106	106

Notes: N = 106.
***p < 0.01, **p < 0.05, *p < 0.1. Robust standard errors in parentheses.

TABLE 6 ANOVA results on the price (quality) effect in the four sectors for the city and the non-city.

	Total NUTS 3	Cities
Non-progressive	−0.158	−0.251
Progressive standardized	0.017	0.008
Manufacturing	−0.245	−0.212
Progressive customized	0.084	0.113
F-test	212.61***	26.06***

Note: *** indicates a p-value lower than 0.01.

TABLE 7 Price (quality) effect: the role of sectors and technology adoption.

Dependent variable: price (quality) effect relative to the NUTS 3 average	(1)	(2)	(3)	(4)	(5)
Progressive standardized (1)	0.175***	0.175***	0.205***	0.242***	−0.176
	(0.017)	(0.017)	(0.020)	(0.019)	(0.144)
Manufacturing (2)	−0.088***	−0.088***	−0.076***	−0.067***	−0.151
	(0.020)	(0.020)	(0.019)	(0.018)	(0.140)
Progressive customized (3)	0.242***	0.242***	0.271***	0.282***	−0.151
	(0.017)	(0.017)	(0.019)	(0.019)	(0.142)
Share of firms adopting cloud services			−0.353***	−1.794***	−2.765**
			(0.128)	(0.287)	(1.151)
Square of the share of firms adopting cloud services				2.805***	
				(0.598)	
Share of firms adopting cloud services in progressive standardized services					2.762**
					(1.157)
Share of firms adopting cloud services in the manufacturing sector					0.978
					(1.141)
Share of firms adopting cloud services in progressive customized services					2.965**
					(1.151)
City dummy		−0.014	0.001	−0.014	−0.013
		(0.020)	(0.020)	(0.018)	(0.013)
Constant	−0.166***	−0.164***	−0.118***	0.025	0.190
	(0.029)	(0.029)	(0.035)	(0.041)	(0.145)
NUTS2 dummies	YES	YES	YES	YES	YES
R-squared	0.624	0.624	0.640	0.680	0.761
Observations	424	424	424	424	424

Notes: N = 424.
***p < 0.01, **p < 0.05, *p < 0.1. Robust standard errors in parentheses.

6 | A STRENGTHENED "TYRANNY OF THE CITY" IN THE 4.0 TECHNOLOGY ERA

As indicated in the previous section, in the 4.0 technology era Baumol's prediction of the negligible productivity growth of the non-progressive services still proves true, as the non-progressive services are those showing the

TABLE 8 Relative price (quality) effect in services: the role of the city.

Dependent variable: price (quality) effect relative to the NUTS 3 average	Progressive customized			Progressive standardized			Non progressive			Manufacturing		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Share of firms adopting cloud services	0.177***	−0.080	0.101**	0.136*	0.919**	0.209**	−3.513**	20.020**	−3.141**	−1.563***	−0.605**	−1.555***
	(0.047)	(0.124)	(0.044)	(0.071)	(0.457)	(0.084)	(1.423)	(8.585)	(1.553)	(0.091)	(0.294)	(0.093)
Square of the share of firms adopting cloud services		0.404*			−1.711*			−86.833***			−2.461***	
		(0.226)			(0.956)			(31.606)			(0.756)	
City dummy	0.014	0.011	−0.025	−0.015	−0.010	0.044	−0.036	−0.039	0.215	−0.000	0.003	0.019
	(0.010)	(0.009)	(0.018)	(0.009)	(0.009)	(0.036)	(0.051)	(0.053)	(0.430)	(0.012)	(0.012)	(0.028)
City dummy x share of firms adopting cloud services			0.161**			−0.248*			−1.844			−0.135
			(0.076)			(0.145)			(3.324)			(0.192)
Constant	0.042***	0.078***	0.057***	0.016	−0.070	0.002	0.263	−1.281**	0.220	−0.018	−0.110***	−0.019
	(0.015)	(0.018)	(0.013)	(0.016)	(0.050)	(0.017)	(0.178)	(0.574)	(0.192)	(0.022)	(0.033)	(0.023)
NUTS2 dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.495	0.534	0.533	0.402	0.427	0.422	0.380	0.425	0.385	0.728	0.733	0.728
Observations	106	106	106	106	106	106	106	106	106	106	106	106

Notes: N = 106.
***p < 0.01, **p < 0.05, *p < 0.1. Robust standard errors in parentheses.

lowest increase in productivity growth even when advanced technology adoption takes place (Table 4). However, the empirical analysis goes a step further in this respect, and proves that the city has specific sources of growth that can avoid the urban crisis. This finds explanations not only in the industrial composition of the city in favour of progressive services, as the critical literature on Baumol suggests, but rather it depends also on the higher 4.0 technology adoption in cities (Table 3).

Undoubtedly, the city achieves productivity advantages more than the non-city through the adoption of cloud technologies. In fact, in order to generate positive advantages, such technologies have to be adopted on a large scale (Table 4, column (4)). This condition is more likely in large cities because of their ability to acquire technology-specific skills, develop collective learning processes and cumulate specific knowledge to exploit the new technological paradigm (Table 3).

However, the city increases its productivity gains irrespective of new technology adoption, through its specialization in progressive services which, in turn, exhibit higher productivity gains when located in large urban areas (Table 5, columns (6) and (9)).

Interestingly enough, the empirical analysis is able to go beyond the sources of urban productivity growth in the traditional sense. The analysis shows that the city can grow because of favourable "terms of trade" in the exchange with the non-city, in line with the expectations of the "counter 4.0 vision" previously described. Empirical results clearly suggest that the pricing advantage of the city still holds. First, the city has a marked specialization in progressive customized services, able to sell at increasing prices (Table 7). Second, and more importantly, the city risks losing its monopoly control over the non-city—when the adoption of 4.0 technologies allows easier spatial diffusion of services—only in the case of large adoption of progressive standardized services (Table 8, column (6)). This risk vanishes in the case of progressive customized services that, on the contrary, only when located in cities reinforce their capacity to sell at increasing prices through the adoption of 4.0 technologies (Table 8, column (9)).

These results confirm the "4.0 counter vision" concerning the existence of an "urban tyranny": urban environments enhance the possibilities of services' differentiation and customization through the adoption of new technologies, leading to price increases and favourable terms-of-trade. This capability complements the higher efficiency/productivity of urban services, adding an income distribution outcomes linked to interregional exchanges.

Summing up, between the two dichotomous predictions of *urban crisis* vs. *urban tyranny*, these results pointed to a more complex picture. By shrinking the category of non-progressive sectors, the adoption of 4.0 technologies eliminated most of the reasons that, on conceptual grounds, may justify an *urban crisis* scenario. However, this is only part of the story. The potential (and actual) spatial diffusion of many progressive services, linked to 4.0 technologies, could endanger the traditional advantage of (large) cities. The analysis reveals that the risk of a ubiquitous diffusion of services happens for standardized ones, while customized services widely remain a prerogative of large cities, assuring them the persistence of a spatial monopoly power. All this witnesses the capacity of the city to grow through both productive and distributive effects. Since both sources of urban growth are fostered in the 4.0 technology era, one can conclude that *the 4.0 technology reinforces, rather than weakens, the role of the city*.

While the present analysis focuses on recent technologies, its implications confirm once more the essence and foundations of cities' leading role in history. One of the main sources of urban power and "opulence" of cities was already stated about 250 years ago by Adam Smith (as pointed out in Camagni, 2023): "The government of towns corporate was altogether in the hands of traders and artificers; and it was the manifest interest of every particular class of them, to prevent the market from being over-stocked, as they commonly express it (…); which is in reality to keep it always under-stocked. (…) In consequence of such regulations, indeed, each class was obliged to buy the goods they had occasion for from every other within the town somewhat dearer (and) none of them were losers by these regulations. *But in their dealings with the country they were all great gainers*; and in these latter *dealings consists the whole trade which supports and enriches every town*." (Smith, 1776/1976, I.x.c.18).

7 | CONCLUSIONS

The value added of the present work resides in the effort to conceptually explain the capacity of the city to remain an efficient economic archetype and to grow also in a technological era in which at a first glance centrifugal forces of dispersion of economic activities in space take over. The city remains the natural locus for high value-added activities and the typical cumulative processes, giving rise to a price premium in multiple ways: a premium for quality, for novelty, for Schumpeterian market power, for a place-linked monopoly power (Camagni, 2020). A dichotomous space is hypothesized, similar to the city–countryside dichotomy of classical economists: the (large) city and the non-city (small cities and rural areas).

The empirical analysis supported such theoretical expectations. The results are striking especially since they are obtained by data that only partially capture the urban premium. The lack of regional price deflators required that the pricing changes be estimated as only stemming from sectoral differences, in the regional sectoral composition. This is an acceptable assumption since the most relevant difference in performance of different regions (e.g., between a global-city region and a small-city region) resides in the sectoral mix (defined on a sufficiently detailed level) due to selective attraction/development of more advanced activities and sorting processes of best talents (Combes et al., 2008, 2012).

However, results could be even stronger if regional-sector deflators were available. Prices can in fact differ among territories for other reasons than the mere sectoral mix. The size of the city can in itself act on urban monopolistic conditions that the city can exert over the non-city through the quality of its production factors (high-skilled labour; high-quality functions), the soft and hard infrastructure offered, the general urban atmosphere that can make large cities more attractive than small and medium ones. All these elements are reflected on an urban premium, which would be much better captured through the availability of regional-sector deflators.

Despite its limits, our analysis witnesses that urban advantage (and wealth) is both productive and distributive in nature, even in an era of advanced technological change. The higher productivity of urban services, and their capacity of selling at growing pricing to the non-city make the contradiction between the city and the non-city still hold despite the era of "overcoming distance" technologies. Assuming once again (after Aydalot & Camagni's, 1986 paper) a dichotomous space, it has been possible to demonstrate against Baumol's expectations the reasons for a persisting positive outlook for the city.

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REFERENCES

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., & Price, B. (2014). Return of the Solow Paradox? IT, productivity, and employment in US manufacturing. *American Economic Review*, *104*(5), 394–399. https://doi.org/10.1257/aer.104.5.394

Acemoglu, D., & Restrepo, P. (2020). Robots and jobs: Evidence from US labor markets. *Journal of Political Economy*, *128*(6), 2188–2244. https://doi.org/10.1086/705716

Aghion, P., Bergeaud, A., Boppart, T., Klenow, P. J., & Li, H. (2019). Missing growth from creative destruction. *American Economic Review*, *109*(8), 2795–2822. https://doi.org/10.1257/aer.20171745

Althoff, L., Eckert, F., Ganapati, S., & Walsh, C. (2021). The geography of remote work NBER Working Paper No. 29181.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics*, *118*(4), 1279–1333. https://doi.org/10.1162/003355303322552801

Aydalot, P., & Camagni, R. (1986). Tertiarisation et développement des métropoles: un modèle de simulation du développement régional. *Revue d'Economie Régionale et Urbaine*, *2*, 171–186.

Barns, O. (2022). “City of London has lost 14% of its restaurants since 2020” *Financial Times*, 14 August. Available at https://www.ft.com/content/f5f59e08-1dd4-41bb-a6f0-714e5c3ae47e, (Accessed: 15 August 2022).

Barras, R. (1986). Towards a theory of innovation in services. *Research Policy*, *15*, 161–173. https://doi.org/10.1016/0048-7333(86)90012-0

Baumol, W. (1967). Macroeconomics of unbalanced growth: The anatomy of urban crisis. *The American Economic Review*, *57*(3), 415–426.

Behrens, K., Kichko, S., & Thisse, J.-F. (2021). “Working from home: Too much of a good thing?” CEPR Discussion Paper DP15669.

Brueckner, J., & Sayantani, S. (2022). Intercity Impacts of work-from-home with both remote and non-remote workers CESifo Working Paper No. 9793.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress and prosperity in a time of brilliant technologies*. W. W. Norton & Company.

Büchi, G., Cugno, M., & Castagnoli, R. (2020). Smart factory performance and Industry 4.0. *Technological Forecasting and Social Change*, *150*, 119790. https://doi.org/10.1016/j.techfore.2019.119790

Burlina, C., & Montresor, S. (2022). On the territorial embeddedness of the fourth industrial revolution: A literature review about how Industry 4.0 meets industrial districts. *Scienze Regionali*, *21*(1), 63–82.

Cairncross, F. (2001). *The death of distance*. Harvard Business Review Press.

Calvino, F., Criscuolo, C., Marcolin, L., & Squicciarini, M. (2018). A taxonomy of digital intensive sectors. OECD Science, Technology and Industry Working Papers, No. 2018/14, OECD Publishing, Paris.

Camagni, R. (2020). Space, land rent and income distribution. *Scienze Regionali - Italian Journal of Regional Science*, *19*(3), 343–372.

Camagni, R. (2023). Adam Smith (1723–1790): Uncovering his legacy for regional science. In P. Batey & D. Plane (Eds.), *Great minds in regional science* (Vol. 2, pp. 13–70). Springer Verlag.

Camagni, R., & Capello, R. (2020). Contributions by Italian scholars to regional science. *Papers in Regional Science*, *99*(2), 359–388. https://doi.org/10.1111/pirs.12510

Camagni, R., Capello, R., & Caragliu, A. (2021). Le città metropolitane: Leader all'interno della gerarchia urbana in Italia? *Archivio di Studi Urbani e Regionali*, *132*, 121–152. https://doi.org/10.3280/ASUR2021-132006

Camagni, R., Capello, R., & Perucca, G. (2022). Beyond productivity slowdown: Quality, pricing and resource reallocation in regional competitiveness. *Papers in Regional Science*, *101*(6), 1307–1330. https://doi.org/10.1111/pirs.12696

Capello, R., Caragliu, A., & Gerritse, M. (2022). Continuous vs. discrete urban ranks: Explaining the evolution in the Italian urban hierarchy over five decades. *Economic Geography*, *98*, 438–463. https://doi.org/10.1080/00130095.2022.2074830

Capello, R., & Lenzi, C. (2021). Industry 4.0 and servitisation: Regional patterns of 4.0 technological transformations in Europe. *Technological Forecasting and Social Change*, *173*, 1–14.

Capello, R., Lenzi, C., & Panzera, E. (2022). The rise of the digital service economy in European regions. *Industry and Innovation*, 1–27. https://doi.org/10.1080/13662716.2022.2082924

Capello, R., Lenzi, C., & Perucca, G. (2022). The modern Solow paradox. In search for explanations. *Structural Change and Economic Dynamics*, *63*, 166–180. https://doi.org/10.1016/j.strueco.2022.09.013

Capestro, M., Di Maria, E., & Bettiol, M. (2022). The effects of Industry 4.0 for firms and territories: Introducing the special issue. *Scienze Regionali, Italian Journal of Regional Science*, *21*(1), 3–12.

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82. https://doi.org/10.1080/10630732.2011.601117

Ciccone, A. (2002). Agglomeration effects in Europe. *European Economic Review*, *46*(2), 213–227. https://doi.org/10.1016/S0014-2921(00)00099-4

Ciffolilli, A., & Muscio, A. (2018). Industry 4.0: National and regional comparative advantages in key enabling technologies. *European Planning Studies*, *26*(12), 2323–2343. https://doi.org/10.1080/09654313.2018.1529145

Combes, P. P., Duranton, G., & Gobillon, L. (2008). Spatial wage disparities: Sorting matters! *Journal of Urban Economics*, *63*(2), 723–742. https://doi.org/10.1016/j.jue.2007.04.004

Combes, P. P., Duranton, G., Gobillon, L., Puga, D., & Roux, S. (2012). The productivity advantages of large cities: Distinguishing agglomeration from firm selection. *Econometrica*, *80*(6), 2543–2594. https://doi.org/10.3982/ECTA8442

Di Liberto, A., & Sideri, M. (2015). Past dominations, current institutions and the Italian regional economic performance. *European Journal of Political Economy*, *38*(C), 12–41. https://doi.org/10.1016/j.ejpoleco.2014.12.006

Djellal, F., Gallouj, F., & Miles, I. (2013). Two decades of research on innovation in services: Which place for public services? *Structural Change and Economic Dynamics*, *27*(C), 98–117. https://doi.org/10.1016/j.strueco.2013.06.005

Duranton, G., & Puga, D. (2020). The economics of urban density. *Journal of Economic Perspectives*, *34*, 3–26. https://doi.org/10.1257/jep.34.3.3

Eckert, F., Ganapati, S., & Walsh, C. (2020). Skilled scalable services: The new urban bias in economic growth, CESifo Working Paper 8705.

European Patent Office - EPO. (2020). Patents and the Fourth Industrial Revolution (EPO), European Patent Office, Handelsblatt Research Institute. http://documents.epo.org/projects/babylon/eponet.nsf/0/06E4D8F7A2D6C2E1C125863900517B88/$File/patents_and_the_fourth_industrial_revolution_study_2020_en.pdf

Fernandez, R., & Palazuelos, E. (2012). European Union economies facing 'Baumol's disease' within the service sector. *Journal of Common Market Studies*, *50*(2), 231–249. https://doi.org/10.1111/j.1468-5965.2011.02222.x

Florida, R., Rodríguez-Pose, A., & Storper, M. (2021). Cities in a Post-COVID world. *Urban Studies*, 1–23. https://doi.org/10.1177/00420980211018072

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, *114*(C), 254–280. https://doi.org/10.1016/j.techfore.2016.08.019

Friedman, T. (2004). *The world of flat*. Farrar, Straus and Giroux.

Gokan, T., Kichko, S., Matheson, J. A., & Thisse, J. (2022). How the rise of teleworking will reshape labor markets and cities, CESifo Working Paper, No. 9952.

Goos, M., Manning, A., & Salomons, A. (2014). Explaining job polarization: Routine-biased technological change and offshoring. *American Economic Review*, *104*(8), 2509–2526. https://doi.org/10.1257/aer.104.8.2509

Griliches, Z. (1992). The search for R&D spillovers. *The Scandinavian Journal of Economics*, *94*, S29–S47. https://doi.org/10.2307/3440244

Guiso, L., Sapienza, P., & Zingales, L. (2004). The role of social capital in financial development. *American Economic Review*, *94*(3), 526–556. https://doi.org/10.1257/0002828041464498

Hartwig, J., & Krämer, H. (2019). The 'growth disease' at 50—Baumol after Oulton. *Structural Change and Economic Dynamics*, *51*(C), 463–471. https://doi.org/10.1016/j.strueco.2019.02.006

Kunzmann, K. (2020). Smart cities After Covid-19: Ten narratives. *disP—the Planning Review*, *56*(2), 20–31. https://doi.org/10.1080/02513625.2020.1794120

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, *6*(4), 239–242.

Liu, S., & Su, Y. (2021). The impact of the Covid-19 pandemic on the demand for density: Evidence from the US housing market. *Economics Letters*, *207*, 110010. https://doi.org/10.1016/j.econlet.2021.110010

Marchetti, C. (1994). Anthropological invariance in travel behaviour. *Technological Forecasting and Social Change*, *47*(1), 75–88. https://doi.org/10.1016/0040-1625(94)90041-8

Mariotti, I. (2021). Il Lavoro a Distanza Svuota le Citta? In M. Bellandi, I. Mariotti, & R. Nisticò (Eds.), *Città nel Covid* (pp. 25–36). Donzelli Editore.

Mazzola, F., & Pizzuto, P. (2020). Resilience and convergence: Short vs. long-run regional effects of economic crises and macroeconomic policies. Scienze Regionali—Italian. *Journal of Regional Science*, *19*(3), 431–452.

McAfee, A., & Brynjolfsson, E. (2017). *Machine, platform, crowd: Harnessing our digital future*. Norton & Company.

Oulton, N. (2001). Must the growth rate decline? Baumol's unbalanced growth revisited. *Oxford Economic Papers*, *53*(4), 605–627. https://doi.org/10.1093/oep/53.4.605

Oulton, N. (2016). The mystery of TFP. *International Productivity Monitor*, *31*, 68–105.

Paiva Santos, B., Charrua-Santos, F., & Lima, T. M. (2018). Industry 4.0: An overview, *Proceedings of the World Congress on Engineering*, Vol II, July 4–6, London, UK.

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, *13*(6), 343–373. https://doi.org/10.1016/0048-7333(84)90018-0

Perucca, G. (2014). The role of territorial capital in local economic growth: Evidence from Italy. *European Planning Studies*, *22*(3), 537–562. https://doi.org/10.1080/09654313.2013.771626

Rullani, F., & Rullani, E. (2018). *Dentro la rivoluzione digitale*. Giappichelli Editore.

Schwab, K. (2017). *The fourth industrial revolution*. Crown Business.

Smith, A. (1776/1976). *An inquiry into the nature and causes of the wealth of nations*, *The Glasgow Edition of the Works and Correspondence of Adam Smith* (Vol. II). Oxford University Press.

Soete, L., & Miozzo, M. (1989). *Trade and development in services: a technological perspective*, United Nations University, Maastricht Economic and Social Research Institute on Innovation and Technology, UNCTAD, New York.

Tether, B. S. (2015). Do services innovate (differently)? Insights from the European Innobarometer Survey. *Industry and Innovation*, *12*, 153–184. https://doi.org/10.1080/13662710500087891

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APPENDIX

TABLE A1 List of variables, source and descriptive statistics.

Name	Source	Mean	Std. dev.	Variance
Δ *Labour productivity relative to the NUTS 3 average*	Authors' own elaborations on ISTAT and AIDA - Bureau Van Dijk data			
Non-progressive		−0.075	0.153	0.023
Progressive standardized		0.018	0.081	0.007
Manufacturing		0.126	0.161	0.026
Progressive customized		−0.046	0.217	0.047
Δ *pricing relative to the NUTS 3 average*	Authors' own elaborations on ISTAT and AIDA—Bureau Van Dijk data			
Non-progressive		−0.158	0.172	0.030
Progressive standardized		0.017	0.028	0.001
Manufacturing		−0.245	0.121	0.015
Progressive customized		0.084	0.036	0.001
Share of firms adopting cloud services	Authors' own elaborations on ISTAT data			
Non-progressive		0.127	0.018	0.0003
Progressive standardized		0.212	0.043	0.002
Manufacturing		0.161	0.070	0.005
Progressive customized		0.209	0.105	0.011