The Optimal Provision of Information and Communication Technologies in Smart Cities

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Abstract

We exploit the public good attributes of information and communication technologies (ICTs) and theoretically analyze an aggregate economy of two smart cities in which ICTs are provided in either a decentralized or a centralized manner. We first determine the *efficient* ICT levels that maximize the aggregate surplus from the provision of ICTs in the two cities. Second, we compute the optimal level of ICT provision in the two cities in a *decentralized* regime in which spending on the ICTs is financed by a uniform tax on the city residents. Third, we ascertain the optimal level of ICT provision in the two cities in a *centralized* regime subject to equal provision of ICTs and cost sharing. Fourth, we show that if the two cities have the *same* preference for ICTs then centralization is preferable to decentralization as long as there is a spillover from the provision of ICTs. Finally, we show that if the two cities have *dissimilar* preferences for ICTs then centralization is preferable to decentralization as long as the spillover exceeds a certain threshold.

Keywords: Information and Communication Technologies, Smart City, Spillover, Uncertainty

JEL Codes: R50, R53, H76

1. Introduction

1.1. Review of the literature

Regional scientists, urban economists, and researchers interested in studying technological change have increasingly begun to devote attention to the concept of a *smart city*. In this regard, the work of Caragliu *et al.* (2011), Peris-Ortiz *et al.* (2017), and Van den Buuse and Kolk (2019) tells us that a fundamental characteristic of smart cities is that they use information and communication technologies (ICTs) to improve urban functions in general and thereby provide a whole host of services designed to benefit the residents of such cities. For instance, Concilio *et al.* (2013) point out that ICTs can be used to promote sustainable lifestyles in and across emergent networks of what they call "smart peripheral cities" in Europe. Bakici *et al.* (2013) focus on a particular European city, namely Barcelona, and document the ways in which this city has become a significant smart city by first coming up with and then implementing a "smart city initiative."

Firmino and Duarte (2016) contend that even though ICTs can be useful in smart cities, there are circumstances in which these technologies enable surveillance and control in public areas and thereby undermine the usefulness of urban public spaces. Paulin (2016) discusses the extent to which the use of ICTs permits the government of a smart city to steer and control systems and what this ability means for what he calls "sustainable governance evolution." After pointing to the many opportunities provided by ICTs to conduct smart urban policy, Kourtit *et al.* (2017) demonstrate how these technologies have actually been used to effectively manage smartphone data systems. This and other such applications reveal the usefulness of ICTs in addressing a variety of problems that fall into the category of "complex urban management" issues.

Tekin (2017) concentrates on Turkey's smart city projects and notes that such projects are successful only when adequate attention is paid to a project's infrastructural dimension, its policy areas and scope, and to key performance indicators. Melo *et al.* (2017) concentrate on Lisbon, Portugal and show that ICTs can be used to provide guidance information to drivers and that the provision of such information reduces travel times and improves the efficiency of road use in this city. Finally, Batabyal and Nijkamp (2019) utilize a dynamic model and chronicle some of the ways in which ICTs can enhance economic growth in smart cities.

1.2. Objective

The various studies discussed in section 1.1 have certainly advanced our understanding of the many ways in which ICTs can and do enhance the functioning of smart cities. This notwithstanding, our central claim in this paper is that the extant literature on smart cities has paid *no* theoretical attention to the question of how ICTs ought to be provided and to the effects of alternate ways of providing ICTs.

Given this lacuna in the literature, we take advantage of the public good characteristics of ICTs and theoretically analyze an aggregate economy consisting of two smart cities[4] in which ICTs can be provided in either a decentralized or a centralized manner. We first ascertain the *efficient* ICT levels that maximize the aggregate surplus from the provision of ICTs in the two cities. Second, we compute the level of ICT provision in the two cities in a *decentralized* regime in which spending on the ICTs is financed by a uniform tax on the city residents. Third, we determine the level of ICT provision in the two cities in a *centralized* regime subject to equal provision of ICTs and equal cost sharing. Fourth, we show that if the two cities have the *same* preference for ICTs then centralization is preferable to decentralization as long as there is a spillover from the provision of ICTs. Finally, we show that if the two cities have *dissimilar* preferences for ICTs then

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[4] There are many real world instances of the kind of aggregate economy we have in mind. Examples include Minneapolis and Saint Paul, Dallas and Fort Worth, Raleigh and Durham, all in the United States, Gatineau and Ottawa in Canada, and Leeds and Bradford in the United Kingdom.

centralization is, once again, preferable to decentralization as long as the spillover exceeds a particular threshold.

The remainder of this paper is organized as follows: Section 2 delineates our theoretical model of smart cities A and B that is adapted from the discussion in Oates (1972). Section 3 computes the efficient ICT levels that maximize the total surplus from the provision of ICTs in cities A and B. Section 4 calculates the level of ICTs made available in cities A and B in a decentralized regime in which spending on the ICTs is financed by a uniform tax on the inhabitants of the two cities. Section 5 determines the level of ICT provision in cities A and B in a centralized regime subject to the condition that ICT provision and the sharing of costs are both the same in the two cities. Section 6 demonstrates that if cities A and B have identical preferences for ICTs then centralization is preferable to decentralization as long as there is a spillover from the provision of ICTs. Section 7 shows that if cities A and B have non-identical preferences for ICTs then centralization is, once again, preferable to decentralization but only if the spillover exceeds a certain threshold. Section 8 concludes and then suggests two ways in which the research described in this paper might be extended.

2. The Theoretical Framework

Consider an aggregate economy that consists of two smart cities that are denoted by the subscript $i = A, B$. These two cities are assumed to have the same population size. In addition, the population in each city i is represented by a continuum of individuals with a mass of unity. There are three goods that we work with in our model. The first is a private good that is denoted by x. The second and the third goods are the ICTs in the two cities that are denoted by t_A and t_B. The reader should note that several researchers have now pointed out that ICTs share the characteristics of public goods.[5] In this regard, consider the case of internet infrastructure. We know that the internet backbone, strictly speaking, is a rivalrous good either because of limited access or because of congestion stemming from limited bandwidth. However, with advances in technology, bandwidth has increased and this has made internet connectivity more of a non-rivalrous good. Therefore, in the remainder of this paper, we shall think of ICTs in the two smart cities A and B as being, in effect, like public goods.

One unit of either t_A or t_B requires c units of the private good to produce. The residents of the two smart cities are *heterogeneous* in the sense that they differ in their preference for ICTs. So, a resident of type α who lives in smart city i has a utility function given by

$$u_{\alpha}(x, t_i, t_{-i}) = x + \alpha\{(1-\beta)\log(t_i) + \beta\log(t_{-i})\}, \tag{1}$$

where $\beta \in [0, \frac{1}{2}]$ measures the degree of the inter-city spillover from the provision of ICTs. To take an example from footnote 4, this means that the provision of ICTs in, for instance, Minneapolis results in a spillover in neighboring Saint Paul and vice versa. The two extreme cases are given by the endpoints of the closed interval $\left[0, \frac{1}{2}\right]$. Specifically, when $\beta = 0$ there is no inter-city spillover and the residents of smart city i care only about the provision of ICTs in their own city. In contrast, when $\beta = \frac{1}{2}$ the residents in our aggregate economy care equally about the provision of ICTs in the two smart cities under study.

In each smart city i, residents with preference type α are assumed to be distributed in accordance with a cumulative distribution function $F_i(\alpha)$ that is defined on the interval $[0, \bar{\alpha}]$ and

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See Micevska (2006), Marks and Williamson (2007), Baron *et al.* (2014), and Coicaud (2016) for a more detailed corroboration of this claim. As pointed out by Hindriks and Myles (2013, p. 148), a public good possesses the properties of non-excludability and non-rivalry. Non-excludable means that if the public good is provided then no consumer can be excluded from consuming it. Non-rivalry means that consumption of the public good by one individual does not diminish the quantity available for consumption available by any other individual.

has mean[6] denoted by $\delta_i < \bar{\alpha}/2$. Now, consistent with the discussion in the previous paragraph of the heterogeneity of the residents in the two smart cities, we suppose that compared to smart city B, smart city A displays a stronger mean preference for ICTs. In symbols, this means that $\delta_A > \delta_B$. This concludes the description of our theoretical framework. We now compute the efficient ICT levels that maximize the total surplus from the provision of ICTs in smart cities A and B.

3. Efficient ICT Levels

We begin by denoting the income of a type α resident of smart city i by M_{α_i}. We can now express the *total* welfare of smart city i as

$$U_i = \int_0^{\bar{\alpha}} dF_i(\alpha)[x_{\alpha_i} - ct_i + \alpha\{(1-\beta)\log(t_i) + \beta\log(t_{-i})\}]. \qquad (2)$$

The aggregate welfare in the two smart cities under study can be written as $W = U_A + U_B$. We also have an aggregate budget constraint and this constraint tells us that we must have

$$\int_0^{\bar{\alpha}} dF_A(\alpha)x_{\alpha_A} + \int_0^{\bar{\alpha}} dF_B\,(\alpha)x_{\alpha_B} = \int_0^{\bar{\alpha}} dF_A\,(\alpha)M_{\alpha_A} + \int_0^{\bar{\alpha}} dF_B\,(\alpha)M_{\alpha_B} - c(t_A + t_B). \qquad (3)$$

In order to maximize the welfare of our aggregate economy, we need to set $\partial W/\partial t_i = 0, i = A, B$.[7] So, let us use equations (2), (3), and then differentiate $W(\cdot)$ with respect to t_A. This gives us

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We suppose that the mean is equal to the median in both smart cities under study. An implication of this supposition is that the preference type distribution functions are symmetrical in nature.

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We assume that the resulting solution is an interior solution.

$$\frac{\partial\{U_A+U_B\}}{\partial t_A} = \int_0^{\overline{\alpha}} dF_A\,(\alpha)\left\{\frac{\alpha(1-\beta)}{t_A} - c\right\} + \int_0^{\overline{\alpha}} dF_B\,(\alpha)\,\frac{\alpha\beta}{t_A} = 0 \tag{4}$$

and we get a similar equation when setting $\partial\{U_A + U_B\}/\partial t_B = 0$. We can now use standard expressions from statistics for the expected value of a random variable---see Taylor and Karlin (1998, pp. 9-15)---to simplify the two first order necessary conditions for an optimum. This gives us

$$\frac{\delta_i(1-\beta)}{t_i} + \frac{\delta_{-i}\beta}{t_{-i}} = c, i = A, B. \tag{5}$$

Solving the system of two equations described by (5) in the two unknowns t_A and t_B, we get the efficient ICT levels that maximize the total surplus in our aggregate economy consisting of smart cities A and B. Let us denote these *efficient* levels by $t_i^E, i = A, B$. We obtain

$$t_i^E = \frac{\delta_i(1-\beta)+\delta_{-i}\beta}{c}, i = A, B. \tag{6}$$

Inspecting equation (6), we see that the efficient ICT levels depend *positively* on the mean preference for ICTs (δ_i, δ_{-i}) in the two smart cities and *negatively* on the number of units of the private good (c) needed to produce and provide the two efficient ICT levels. Our next task is to determine the ICT levels in smart cities A and B in a decentralized setting in which spending on the ICTs is financed by a uniform tax on the inhabitants of the two cities.

4. Decentralized Provision of ICTs

In the decentralized regime, each smart city *independently* chooses[8] ICT level t_i to maximize total city welfare U_i. Public spending on ICTs in each smart city is financed by a uniform tax on the residents of the city. This means that if the ith smart city provides ICTs at level t_i then each inhabitant of smart city i pays a tax given by $\tau_i = ct_i$. Given these changes, the expression for U_i is now given by

$$U_i = \int_0^{\overline{\alpha}} dF_i\,(\alpha)\big[M_{\alpha_i} - ct_i + \alpha\{(1-\beta)\log(t_i) + \beta\log(t_{-i})\}\big]. \qquad (7)$$

The first order necessary conditions for an interior optimum are given by setting $\partial U_i/\partial t_i = 0, i = A, B$. Doing this and then simplifying the resulting expressions gives us the two optimal ICT levels under decentralization. Denoting these two levels by $t_i^D, i = A, B$, we get

$$t_i^D = \frac{\delta_i(1-\beta)}{c}, i = A, B. \qquad (8)$$

Inspecting equation (8), we see that like the efficient ICT levels case analyzed in section 3 and described by equation (6), the optimal decentralized ICT levels also depend *positively* on the mean preference for ICTs (δ_i) in the two smart cities and *negatively* on the number of units of the private good (c) needed to produce and provide the two decentralized ICT levels. That said, subtracting the right-hand-side (RHS) of equation (8) from the RHS of equation (6), we see that

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If these choices are not independent but sequential then our findings in this section may well change.

$$t_i^E - t_i^D = \frac{\delta_{-i}\beta}{c} > 0 \tag{9}$$

as long as $\beta > 0$.

Equation (9) tells us that as long as there is an ICT provision related spillover between smart cities A and B, the efficient ICT levels that are provided are *greater* in magnitude than the ICT levels provided in the decentralized regime. Further, in the special case in which there is no spillover and hence $\beta = 0$, the efficient and the decentralized ICT levels coincide. We now ascertain the level of ICT provision in a centralized regime subject to the condition that ICT provision and the sharing of costs are the same in smart cities A and B.

5. Centralized Provision of ICTs

In the centralized regime, the pertinent ICT levels in the two smart cities are chosen by a central authority with two specific conditions. First, there is the equal provision requirement and this means that $t_A = t_B$. Second, there is equal cost sharing of the ICTs that are provided and this means that each inhabitant in either smart city pays $\tau_i = c(t_A + t_B)/2$. These two conditions together ensure that the central authority displays no favoritism towards either smart city A or B. With these two changes, the expression for U_i now is

$$U_i = \int_0^{\overline{\alpha}} dF_i\,(\alpha)\big[M_{\alpha_i} - ct + \alpha\log(t)\big]. \tag{10}$$

To determine the optimal ICT level or t, we need to solve for $d\{U_A + U_B\}/dt = 0$. Using equation (10) and then differentiating with respect to t, we get

$$\frac{d\{U_A+U_B\}}{dt} = \int_0^{\overline{\alpha}} dF_A\,(\alpha)\left\{\frac{\alpha}{t} - c\right\} + \int_0^{\overline{\alpha}} dF_B(\alpha)\left\{\frac{\alpha}{t} - c\right\} = 0. \tag{11}$$

Using standard expressions from statistics for the expected value of a random variable---see Taylor and Karlin (1998, pp. 9-15)---we can simplify the RHS of equation (11). This gives us

$$\frac{\delta_A+\delta_B}{t} - 2c = 0. \qquad (12)$$

Denoting the optimal ICT level in the centralized setting by t^C, we get

$$t^C = \frac{\delta_A+\delta_B}{2c}. \qquad (13)$$

Inspecting equation (13), we see that like the cases analyzed in sections 3 and 4, the optimal centralized ICT level depends *positively* on the mean preference for ICTs in the two smart cities (δ_A, δ_B) and *negatively* on the number of units of the private good (c) needed to produce and provide the centralized ICT level. Subtracting the right-hand-side (RHS) of equation (13) from the RHS of equation (6), we see that

$$t_i^E - t^C = \frac{(\delta_i-\delta_{-i})(1-2\beta)}{2c}. \qquad (14)$$

Now recall that the spillover parameter $\beta \in [0, \frac{1}{2}]$ and that $\delta_A > \delta_B$. Using these two pieces of information along with the result contained in equation (14), we deduce that

$$t_A^E \geq t^C \geq t_B^E. \qquad (15)$$

The result in (15) contains an interesting but negative finding about the centralized provision of ICTs in the two smart cities under study. Specifically, we see that in the centralized regime, ICTs will be *underprovided* in the smart city that has a stronger mean preference for these technologies ($t_A^E \geq t^C$) and *overprovided* in the smart city that has a weaker mean preference for these same technologies ($t^C \geq t_B^E$). We now want to show that if the smart cities A and B have identical preferences for ICTs then centralization is preferable to decentralization as long as there is a spillover from the provision of ICTs.

6. Identical Preferences for ICTs

We model the identical preferences for ICTs in the two smart cities by supposing that $\delta_A = \delta_B$. Also, since the spillover from the provision of ICTs is positive, we have $\beta > 0$. The welfare of the ith smart city in the decentralized regime is given by equation (7) and therefore equation (8) gives us the optimal ICT levels in this regime. So, using this last result and denoting the total income in the ith smart city by M_i, we can now write

$$U_i^D = M_i - \delta_i(1-\beta) + \delta_i \left[(1-\beta)log\left\{\frac{\delta_i(1-\beta)}{c}\right\} + \beta log\left\{\frac{\delta_{-i}(1-\beta)}{c}\right\}\right]. \qquad (16)$$

Given equation (16), the welfare in our aggregate economy of smart cities A and B can be written as

$$W^D = M - (\delta_A + \delta_B)(1-\beta) + (\delta_A + \delta_B)log\left\{\frac{1-\beta}{c}\right\} + \{\delta_A(1-\beta) + \delta_B\beta\}\log(\delta_A) + \{\delta_A\beta + \delta_B(1-\beta)\}\log(\delta_B), \qquad (17)$$

where we have used $M = M_A + M_B$ to denote the total income in our aggregate economy.

When ICTs are provided to the two smart cities in the centralized regime, the welfare of the ith smart city is given by equation (10) and the optimal ICT level or t^C is given by equation (13). Using these two pieces of information, we can write the welfare of the ith smart city as

$$U_i^C = M_i - \frac{\delta_i+\delta_{-i}}{2} + \delta_i log\left\{\frac{\delta_i+\delta_{-i}}{2c}\right\}, \tag{18}$$

and the welfare of our aggregate economy as

$$W^C = M - (\delta_A + \delta_B) + (\delta_A + \delta_B) log\left\{\frac{\delta_A+\delta_B}{2c}\right\}. \tag{19}$$

Because $\delta_A = \delta_B = \delta$, the two aggregate welfare expressions in equations (17) and (19) simplify to

$$W^D = M - 2\delta(1-\beta) + 2\delta log\left\{\frac{1-\beta}{c}\right\} + 2\delta\log\{\delta\} \tag{20}$$

and

$$W^C = M - 2\delta + 2\delta log\left\{\frac{\delta}{c}\right\}. \tag{21}$$

Subtracting the RHS of equation (20) from the RHS of equation (21), we are able to confirm that

$$W^C - W^D = -2\delta\{\beta + \log(1-\beta)\} > 0, \tag{22}$$

as long as $\beta \in \left[0, \frac{1}{2}\right]$. We have just demonstrated that when there is an inter-city spillover from the provision of ICTs, relative to decentralization, the centralized provision of such technologies gives rise to a *higher* level of welfare. In contrast, when there is no spillover and hence $\beta = 0$, the welfare levels under centralization and decentralization are *identical*. We now proceed to our final task in this paper and that is to demonstrate that if smart cities A and B have non-identical preferences for ICTs then, once again, centralization is preferable to decentralization as long as the technological spillover β exceeds a certain threshold.

7. Dissimilar Preferences for ICTs

We account for the dissimilar preferences for ICTs in the two smart cities by supposing that the inequality $\delta_A > \delta_B$ holds. Next, we write the expression corresponding to equation (22) in the case where the two smart cities have dissimilar preferences for ICTs. After some algebraic steps, we get

$$W^C - W^D = -\beta(\delta_A + \delta_B) - (\delta_A + \delta_B)\log(1-\beta) + (\delta_A + \delta_B)log\left\{\frac{\delta_A + \delta_B}{2}\right\} - [\{\delta_A(1-\beta) + \delta_B\beta\}\log(\delta_A) + \{\delta_A\beta + \delta_B(1-\beta)\}\log(\delta_B)]. \quad (23)$$

Focusing for the moment on the parameter β denoting the technological spillover, we can rewrite the expression on the RHS of equation (23) as

$$W^C - W^D = \Delta W(\beta), \quad (24)$$

where Δ denotes the change in welfare.

Evaluating $\Delta W(\beta)$ at $\beta = 0$, we get

$$\Delta W(0) = (\delta_A + \delta_B) log\left\{\frac{\delta_A+\delta_B}{2}\right\} - \delta_A \log(\delta_A) - \delta_B \log(\delta_B). \quad (25)$$

After some algebraic steps, the RHS of equation (25) can be simplified and signed. In particular, because $\delta_A > \delta_B$, this process gives us

$$\Delta W(0) = \delta_A \left[log\left\{\frac{1}{2}\left(\frac{\delta_B}{\delta_A} + 1\right)\right\} + \frac{\delta_B}{\delta_A} log\left\{\frac{1}{2}\left(\frac{\delta_A}{\delta_B} + 1\right)\right\}\right] < 0. \quad (26)$$

Next, we want to evaluate $\Delta W(\beta)$ at $\beta = \frac{1}{2}$. This gives us

$$\Delta W\left(\frac{1}{2}\right) = (\delta_A + \delta_B) log\left\{\frac{\delta_A+\delta_B}{2}\right\} - \frac{(\delta_A+\delta_B)}{2} - (\delta_A + \delta_B) log\left(\frac{1}{2}\right) - \frac{(\delta_A+\delta_B)}{2}\{\log(\delta_A) + \log(\delta_B)\}. \quad (27)$$

After a couple of steps of algebra, the RHS of equation (27) can also be simplified and signed. This time we get

$$\Delta W\left(\frac{1}{2}\right) = (\delta_A + \delta_B)\left[log\left\{\frac{\delta_A+\delta_B}{\sqrt{\delta_A\delta_B}}\right\} - \frac{1}{2}\right] > 0. \quad (28)$$

Let us now differentiate the expression for $\Delta W(\beta)$ in equation (23) with respect to the spillover parameter β. This gives us

$$\frac{d\{\Delta W(\beta)\}}{d\beta} = (\delta_A + \delta_B)\frac{\beta}{1-\beta} + (\delta_A - \delta_B) log\left(\frac{\delta_A}{\delta_B}\right) > 0, \quad (29)$$

as long as $\delta_A > \delta_B$. Our analysis thus far in this section leads to three results. First, we showed that $\Delta W(0) < 0$. Second, we pointed out that $\Delta W\left(\frac{1}{2}\right) > 0$. Finally, since differentiability implies continuity,[9] we have shown that $d\{\Delta W(\beta)\}/d\beta$ is both continuous and monotonically increasing in β. These three results and the mean value theorem[10] together tell us that there exists a *threshold* $\beta^* \in \left(0, \frac{1}{2}\right)$ such that $\Delta W(\beta^*) = 0$ and $\Delta W(\beta) > 0$ for $\beta \in \left(\beta^*, \frac{1}{2}\right]$.

Our analysis of the provision of ICTs in smart cities A and B shows that there is a clear *tradeoff* between the centralization and the decentralization regimes. Specifically, under centralization, an excessively *high* level of ICTs are provided in the smart city with a *lower* preference for these technologies and an insufficiently *low* level of ICTs are provided in the smart city with a *higher* preference for these same technologies. In addition, when there is an inter-city spillover from the provision of ICTs, relative to decentralization, centralization leads to *higher* welfare in the aggregate economy of two smart cities. Finally, if the inter-city spillover from ICT provision is sufficiently strong, then the additional utility obtained by the residents of the smart city with a stronger preference for the ICTs provided in the smart city with a weaker preference for such provision compensates them for the *loss* of utility stemming from the *underprovision* of ICTs in their own smart city. As a result, total welfare in this last instance with centralized ICT provision is *higher* than what it would be with decentralized provision. This completes our analysis of the optimal provision of ICTs in an aggregate economy consisting of two smart cities.

9 See Theorem 5.2 in Rudin (1976, p. 104) for additional details.

10 See Rudin (1976, pp. 107-108) for a textbook exposition of the mean value theorem.

8. Conclusions

In this paper, we exploited the public good features of ICTs and theoretically analyzed an aggregate economy of two smart cities in which ICTs could be provided in either a decentralized or a centralized manner. We first determined the efficient ICT levels that maximized the aggregate welfare from the provision of ICTs in the two smart cities. Second, we computed the optimal levels of ICT provision in the two cities in a decentralized regime in which spending on the ICTs was financed by a uniform tax on the city residents. Third, we ascertained the optimal level of ICT provision in the two cities in a centralized regime subject to equal ICT provision and cost sharing. Fourth, we showed that if the two cities have the same preference for ICTs then centralization was preferable to decentralization as long as there was a spillover from the provision of ICTs. Finally, we showed that if the two cities have dissimilar preferences for ICTs then centralization was, once again, preferable to decentralization as long as the spillover exceeded a critical threshold.

The analysis in this paper can be extended in a number of different directions. In what follows, we suggest three potential extensions. First, we can ask how ICT using smart cities function during an economic crisis. We have not studied this question and therefore it would be useful to determine how ICTs might be used to improve the quality of life of the residents of a smart city so that they are able to participate meaningfully in this city's cultural and political life during a crisis. Second, it would be helpful to determine the extent to which the methodology employed by, for instance, Oladi (2004) can be used to study investments in ICTs by smart cities in alternate strategic environments. Finally, one could examine how ICTs might be used to bring about enhancements in the governance of and the institutions in smart cities so that such cities endeavor to meet the twin objectives of environmental and financial sustainability. Studies that analyze these aspects of the underlying problem in smart cities will provide additional insights into the nexuses between the use of ICTs on the one hand and economic welfare on the other.

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