The Effects Of Improvements In Information Technology On Growth Of Cities: A Model With Multiple Activities

Alexandros Panayides, (E-mail: panayidesa@wpunj.edu), William Paterson University

Abstract

This paper extends my previous research in this field by developing a model where the economic agents are no longer engaged in the same productive activity. In this paper I develop a model where individuals involved in a relationship use two modes of interaction, face-to-face interactions and electronic communications. Specifically the model tries to answer the following question: If there is improvement in electronic communications, under what conditions will more activities choose city locations?

1. Introduction

In my recent research in this field I have originally develop a model where individuals involved in a relationship are allowed to use both modes of interaction[1], face-to-face and electronic communications, Panayides (2001). In that model I assumed that better electronic communications do not increase the payoff from face-to-face interactions, and second, that more valuable face-to-face interactions do not increase the payoff from electronic communications. In an extended model both of these assumptions were relaxed, Panayides (2002). Both versions of the model showed that improvements in communications technology increases the time spent on electronic interactions, but the effect on face-to-face interactions is ambiguous. Specifically, improvements in communications technology increase the time spent on face-to-face interactions only if the two modes of interaction are complements. In this paper the economic agents are no longer engaged in the same productive activity as was assumed on the previous two version of the model. In particular, this paper develops an urban model where the following question is answered: If there is improvement in electronic communications, under what conditions will more productive activities choose city locations? The paper is organized as follows: Section two provides a quadratic function so that face-to-face interactions and electronic communications are substitutes, and section three such that face-to-face interactions and electronic communications are complements. Section four provides concluding remarks.

2. Model I: Face-to-face interactions and electronic communications are substitutes.

In this section we construct an urban model using a quadratic function that is so constructed that face-to-face interactions and electronic communications are substitutes. Under the assumption that cities facilitate face-to-face interactions, the focus in this section is to examine the following: If there is improvement in electronic communications, under what conditions will more activities choose city locations?

The urban model is constructed as follows. There are two workplaces, the city and the hinterland. In particular, city workers/residents must pay higher commuting and/or housing costs, while hinterland residents pay no commuting costs and may purchase the cheapest possible housing. These differences in commuting cost and rent

[1] In Gaspar and Glaeser (1998) only one mode of interaction is allowed in the relationship.

premiums for housing are denoted by HN, where N is the population of the city. As stated above, the other difference between the two locations is that, we assume that the city facilities face-to-face interactions, i.e., the fraction of face-to-face interactions that is productive is higher in the city than in the hinterland.

Consider a representative agent involved in relationships with other agents. The relationships are conducted using both electronic communications and face-to-face contact. The payoff of the relationships depends on the time spent on electronic and face-to-face interactions. For a city resident the payoff and net payoff functions are given as follows,

$$V^c = a_e t_e^c + a_f b^c t_f^c - \frac{1}{2} a_{ee} t_e^{2c} - \frac{1}{2} a_{ff} b^{2c} t_f^{2c} - a_{ef} t_e^c b^c t_f^c, \tag{1}$$

$$\Pi^c = a_e t_e^c + a_f b^c t_f^c - \frac{1}{2} a_{ee} t_e^{2c} - \frac{1}{2} a_{ff} b^{2c} t_f^{2c} - a_{ef} t_e^c b^c t_f^c - c\left(t_e^c + t_f^c\right) - HN - R, \tag{2}$$

while the payoff and net payoff for a hinterland resident are given as follows,

$$V^h = a_e t_e^h + a_f b^h t_f^h - \frac{1}{2} a_{ee} t_e^{2h} - \frac{1}{2} a_{ff} b^{2h} t_f^{2h} - a_{ef} t_e^h b^h t_f^h, \tag{3}$$

$$\Pi^h = a_e t_e^h + a_f b^h t_f^h - \frac{1}{2} a_{ee} t_e^{2h} - \frac{1}{2} a_{ff} b^{2h} t_f^{2h} - a_{ef} t_e^h b^h t_f^h - c\left(t_e^h + t_f^h\right) - R,$$ [2]

where: t_e is the time spent on electronic communications,

t_f is the time spent on face-to-face communications,

b is the fraction of face-to-face communication that is productive[3],

a_e is the parameter that increases the productivity of electronic communications,

a_f is the parameter that increases the value of face-to-face interactions,

R denotes the agricultural rent.

The goal here is to find out under what conditions is the difference in the net payoffs with respect to a_e positive. In other words,

$$\frac{\partial\left(\Pi^c - \Pi^h\right)}{\partial a_e} = \left[\frac{\partial V^c}{\partial a_e} - \frac{\partial V^h}{\partial a_e}\right] = t_e^c - t_e^h. \tag{4}$$

The condition for (4) to be positive is that $t_e^c > t_e^h$. However, this result will not hold because as shown in Panayides (2001) if the two modes of interaction are substitutes then $\frac{\partial t_e}{\partial b} < 0,$ implying that improvements in electronic communications cause the city residents to spend less time in electronic interactions and hence the city to shrink.

[2] c denotes the city and h the hinterland.

[3] The assumption that cities facilitate face-to-face interactions implies that $b^c > b^h$.

3. Model II: Face-to-face interactions and electronic communications are complements

In this section we construct an urban model using a quadratic function that is so constructed that face-to-face interactions and electronic communications are complements. For a city resident the payoff and net payoff functions are now given as follows,

$$V^c = a_e t_e^c + a_f b^c t_f^c - \frac{1}{2} a_{ee} t_e^{2^c} - \frac{1}{2} a_{ff} b^{2^c} t_f^{2^c} + a_{ef} t_e^c b^c t_f^c, \tag{5}$$

$$\Pi^c = a_e t_e^c + a_f b^c t_f^c - \frac{1}{2} a_{ee} t_e^{2^c} - \frac{1}{2} a_{ff} b^{2^c} t_f^{2^c} + a_{ef} t_e^c b^c t_f^c - c\left(t_e^c + t_f^c\right) - HN - R, \tag{6}$$

while the payoff and net payoff for a hinterland resident are given as follows,

$$V^h = a_e t_e^h + a_f b^h t_f^h - \frac{1}{2} a_{ee} t_e^{2^h} - \frac{1}{2} a_{ff} b^{2^h} t_f^{2^h} + a_{ef} t_e^h b^h t_f^h, \tag{7}$$

$$\Pi^h = a_e t_e^h + a_f b^h t_f^h - \frac{1}{2} a_{ee} t_e^{2^h} - \frac{1}{2} a_{ff} b^{2^h} t_f^{2^h} + a_{ef} t_e^h b^h t_f^h - c\left(t_e^h + t_f^h\right) - R. \tag{8}$$

Differentiating the difference in the net payoffs with respect to a_e yields

$$\frac{\partial\left(\Pi^c - \Pi^h\right)}{\partial a_e} = \left[\frac{\partial V^c}{\partial a_e} - \frac{\partial V^h}{\partial a_e}\right] = t_e^c - t_e^h. \tag{9}$$

We can see that equations (4) and (9) are the same. In contrast to (4), this result does hold. As shown in Panayides (2001), if the two modes of interaction are complements then $\frac{\partial t_e}{\partial b} > 0,$ implying that improvements in electronic communications cause city residents to spend more time in electronic interactions and hence the city to grow. Thus, an improvement in electronic communications will yield a higher marginal payoff in the city if the city residents spend more time on electronic communications than the hinterland residents, which they do in case the modes of interaction are complements. This then implies that more activities will locate in the city, which causes the city to expand.

4. Conclusion

In this paper I have expanded my previous research that examines how the improvements in communications technology will affect the growth of cities. Specifically, I expanded the previous two versions of the model, found in Panayides (2001) and Panayides (2002), by no longer assuming that the economic agents are engaged in the same productive activity. In particular, this paper develops an urban model where the following question is answered: If there is improvement in electronic communications, under what conditions will more productive activities choose city locations? The model is so constructed that the modes of interaction, face-to-face interactions and electronic communication, first are substitutes for one another and they are complements. The model shows that if the two modes of interaction are complements, improvements in electronic communications yield a higher payoff for city residents than the hinterland residents. This then implies that more activities will locate in the city, which causes the city to expand.

5. References

1. Gaspar and Glaeser (1998), "Information Technology and the Future of Cities", *Journal of Urban Economics*, 43, 136-156.
2. Knoke, K. (1996), *Bold New World: The Essential Road Map to the Twenty-First Century*, Kodansha, New York.
3. Naisbitt, R. (1995), *The Global Paradox*, Avon Books, New York.
4. Negroponte, N. (1995), *Being digital*, Vintage Books, New York.
5. Panayides, A. (2001), "The effects of Improvements in Information Technology on Growth of Cities", Papers and proceedings *Conference of the American Society of Business and Behavioral Sciences.*
6. Panayides, A. (2002), "The effects of Improvements in Information Technology on Growth of Cities: An Extension", *International Business and Economics Research Journal*, 1 (11).
7. Panayides, A. (2004), "Do the Advances in Communication Technology Affect City Size?" *Journal of Business and Economic Studies*, forthcoming.
8. Toffler, A. (1980), *The Third Wave*, Bantam Books, New York.

Notes