Appendix:

The teleservice scenario: Since manufacturing takes place in the city and thuswe obtain fro $p^*_M = p_M t_M$

$$\frac{w^*}{w} = t_A^{\gamma-1} t_M^{\gamma}.$$

Since the question for the service firm is whether to move to the city, the wage change is given by w/w^*. In addition transport costs no longer accrue. Thus, the relative value of sales of the relocating firmis given by V/V^*

$$\frac{V}{V^*} = \left(\frac{w}{w^*}\frac{1}{c_c}\right)^{1-\sigma}.$$

Therefore relocation is profitable if

$$v = (t_A^{\gamma-1} t_M^{\gamma})^{\sigma} c_c^{\sigma-1} > 1.$$

The service city scenario: With manufacturing in the provinces and services in the city we have $n^*_I = 0$ and $p_M = p^*_M t_M$. Together with equation(11) this changes equation (14)to

$$\frac{w}{w^*} = t_A^{1-\gamma} t_M^{\gamma}.$$

Since the question for the service firm is again whether to move to the provinces, the relative wage is w^*/w and transport costs are zero. Thus, the relative value of sales of the relocating firm V/V^* is given by

$$\frac{V^*}{V} = \left(\frac{w^*}{w}\frac{1}{c_c}\right)^{1-\sigma}.$$

Therefore relocation is profitable if

$$v^* = (t_A^{1-\gamma} t_M^{\gamma})^{\sigma} c_c^{\sigma-1} > 1.$$

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teleworking costs. This would transform the envsioned service city into a virtual city if not service firms deny their employees teleworking. They might have an incentive to do so if agglomeration externalities vanish when their employees telework and thereby save the service city.

that the agglomeration externalities vanish if all service workers engage in teleworking. Therefore service producers have an incentive to deny their employees this possible use of the information highway and thereby save the city.

IV. Summary

In this paper we have studied possible consequences from building an information highway for the location of economic activity in the framework of a *Krugman* (1991) type model of economic geography. We have identified these advancements in information and communication technology with a decrease in transportation costs for intermediate services in the first part and as a decrease in teleworking costs in the second.

Starting from a situation where all production (except agriculture) is concentrated in the city, building an information highway might induce firms as well as households to relocate to the provinces. Firms can be lured by lower wages and households by the combination of lower living costs and the possibility to keep the higher city wage. While low communication costs are necessary for a relocation process to start, they are not sufficient. For service firms relocation is only profitable if the fall in costs due to lower wages outweighs the communication costs. For households, in turn, lower (relative) wages in the provinces are only acceptable if transport costs for the agricultural produce are high and those for industrial goods are low. If costs of living in the rural region are low enough, households might even move to the provinces and start teleworking, even if the firms prefer to remain in the city. For this to occur, the lower living costs must at least compensate for the costs of teleworking.

A situation with services in the rural area and manufacturing in the city turned out to be unstable. It is always more profitable for manufacturing firms to relocate to the provinces since wages are lower and communication costs for intermediate services can be avoided.

The model also makes some predictions about the feasibility of a service city which is a very popular vision among politicians. This pattern is characterized by a concentration of services in the urban and a spread of manufacturing over the rural region. Such an equilibrium is only feasible if positive locational externalities for the service producers from locating close to each other are large enough to offset the gains from locating closer to their customers, the providers of consumption goods. Without this additional ‘ad hoc’ assumption of agglomeration externalities, the service city is not a stable equilibrium. Furthermore, even if such a technological externality exists for firms, households will move to the provinces whenever the information highway leads to a sufficient decrease in

Consider the city case first: all firms and workers – except agricultural – are located in the city. A houshold decides to move to the provinces if its real income as city dweller (city wage divided by city price level) is smaller than his real income as rural dweller (city wage adjusted for the costs of teleworking divided by rural price level). Defining a new variable ν_H^* as real disposable rural to urban income, the condition to move to the provinces is given as

$$v_H^* = \frac{w/t_H}{p_A^{*1-\gamma} p_M^{*\gamma}} / \frac{w}{p_A^{1-\gamma} p_M^{\gamma}} = \frac{t_A^{1-\gamma} p_M^{\gamma}}{t_H p_M^{*\gamma}} > 1.$$

Taking into account that $p_M^* = p_M t_M$ and $p_A = p_A^* t_A$ simplifies the condition to:

$$v_H^* = \frac{t_A^{1-\gamma}}{t_H t_M^{\gamma}} > 1. \qquad (22)$$

Equation (22) shows that a fall in t_H, the cost of teleworking, increases v_H^*, thus making a relocation decision more advantageous. Note however, that such a decrease is not sufficient to make the city equilibrium for households unstable: If transportation costs for manufactures are large relative to those for agricultural products and if their share in consumption, γ, is relatively large, then v_H^* can be smaller unity even with no teleworking costs ($t_H = 1$). In this case the price level in the provinces is higher than in the city and households prefer to stay in the urban region.

Now, consider the service city scenario. All service production takes place in the city and all manufacturing in the provinces. We have already noted above that such an equilibrium is only sustainable if positive technological location externalities for service production exist. Since only service workers can make use of the information highway, the household decision to discuss is that of a service household in the city thinking of moving into the rural area. Similarly to the discussion above, it will do so if

$$\upsilon_H^* = \frac{w/t_H}{p_A^{*1-\gamma} p_M^{*\gamma}} / \frac{w}{p_A^{1-\gamma} p_M^{\gamma}} = \frac{t_A^{1-\gamma} t_M^{\gamma}}{t_H} > 1. \qquad (23)$$

If there are any transportation costs for the final output goods and if the information highway will decrease the cost of long-distance work sufficiently, the service *workers* will move to the rural area. Service *firms*, however, will remain in the city as long as the locational externalities are large enough. As consequence, the service city becomes a virtual city. While this is an interesting outcome, it is probably more realistic to assume

III. Locational Patterns and Teleworking

So far we have always assumed that workers live in the region of their employment. The main focus was therefore on the location of production. However, one of the first things coming to peoples' minds when discussing possible consequences from the information highway is an increase in teleworking activity: Workers are enabled to conduct their work from home, which could reduce commuting activity and might even lead to migration from cities to the rural area (or the other way round). We will confine ourselves to the migration consequence in this section and discuss the workers' choice of location for housing in the same way as we have analyzed the firms' location decisions above. This is done by reconsidering the two locational scenarios from the previous section which turned out to be possibly stable for firms (metropolis and service city) and introduce the possibility to telework.

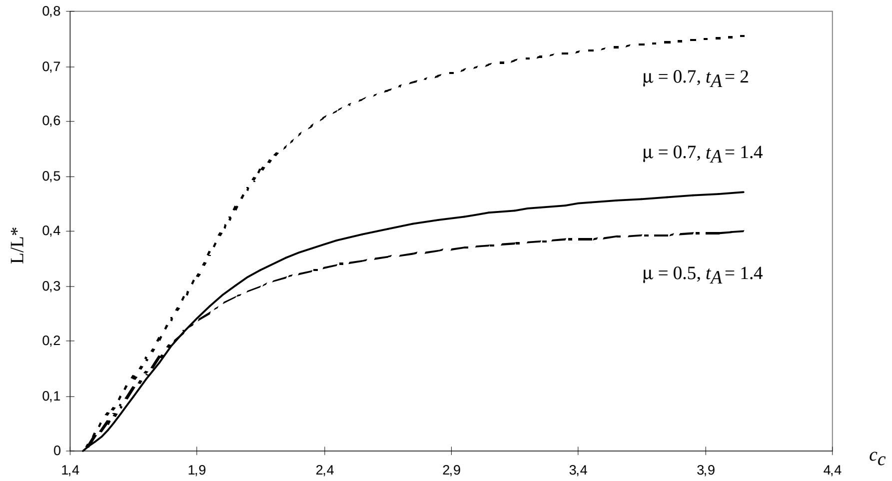
Suppose that the conditions for stability of locational patterns derived in the previous section are met. In this case there are currently no incentives for firms to change their location. Suppose further that initially all workers live in the area where their employer produces. Now the information highway is set up and makes it possible for individuals to move to a 'nicer' place to live – which means a cheaper place – while keeping their occupation and meeting their obligations via teleworking. If an individual worker has an incentive to move, the household location pattern is said to be unstable. Due to such household relocation the firm location pattern changes, too. More manufacturing output is then produced in the target region of household relocation and less in the source region. This, in turn, influences the decision of service producers who want to locate close to their customer base.

We assume for simplicity that only service workers can engage in teleworking and manufacturing workers have to be physically present. Furthermore it is assumed that teleworking is costly and that firms are indifferent about the teleworking decisions of their employees. Since there are also no productivity differences between both types of workers (teleworking and not teleworking), firms pay both types the same wage: households must bear the costs of teleworking themselves which is modelled in the way that the net wage for a teleworking individual is only a fraction $1/t_H$ of the wage for an employee living close to his workplace.[5]

5. This poses the question who builds the information highway and how the costs appear in the economy again as expenses. We abstract from this point and simply assume that service workers can spend their wages either on goods or on the information highway.

equations (1) - (8) and (11) could be simplified to a system of equations in $\tilde{L}, \tilde{p}_M, \tilde{P}_I, \tilde{p}_I, \tilde{w}, \tilde{n}, \tilde{y}_M$, where the tilde denotes the relation of city versus provincial value for the respective variable. This system of equations has been solved numerically with the parameter values $\gamma = 0.6$, $\sigma = 5$, $\beta_I = 4$, and $\alpha_I = 20$ which should be reasonable values. Figure 1 shows the regional distribution of labor $\tilde{L}$ as a measure for the relative size of both regions for three different simulations. In the first run we have chosen $\mu = 0,7$ and $t_A = 1.4$. In the second run, μ has been decreased to $\mu = 0.5$ and in the third t_A has been raised to $t_A = 2$

Figure 1: *Communication Costs and the Regional Distribution of Labor.*



First of all, the simulations show that a fall in the cost of communication leads to a less urbanized economy – just as it raises the inclination of service firms in the service city scenario to relocate to the provinces. Furthermore, a comparsion of the different curves shows that with large transport costs for agricultural goods a decrease in cc leads to a larger relocation to the provinces than with a lower t_A. Likewise, the larger μ, the share of intermediate services in manufacturing production, the stronger is the reaction of $\tilde{L}$ to a change in communication cost c_c. Overall, the long-run outcome in this model is even a worse scenario for cities in the presence of an information-highway than the short-run.

This outcome might come as a surprise to inhabitants of a ‘service metropolis’ like New York or London and as a disappointment to mayors of cities like Berlin that see their city’s future in becoming a service city. A factor that can make such a scenario an equilibrium are technological externalities which, however, are a quite elusive concept. Nevertheless, it is often argued that positive non-pecuniary agglomeration externalities exist for certain services like research or financial services. Production costs of these services are said to be lower whenever many similar producers gather together at a single place than in a situation where they produce far away from others.

We can introduce such externalities in a rather simple way into the model and then reconsider the decision problem for a service firm: Assume that variable production costs in the city, where service firms produce in close proximity, are only a fraction η as large as in the provinces. Then a firm which wants to move to the rural region, looses its cost advantage. Therefore in the metropolis scenario equation(15)changes into

(20) $$v^* = (t_A^{1-\gamma} t_M^{-\gamma})^{\sigma} c_c^{1-\sigma} \eta^{\sigma-1} > 1.$$

Thus, the smaller η, implying a more important locational externality, the smaller v^*. The stability of the city equilibrium is affirmed by the externality.

The externality has no influence on the second equilibrium, the teleservice scenario. For the decision of a single service firm it does not matter whether it produces alone in the provinces or is the single producer in the city. A critical mass of service producers in the city would be necessary for positive externalities to exist.

Last, in the service city scenario condition(19)changes into:

(21) $$v^* = (t_A^{1-\gamma} t_M^{\gamma})^{\sigma} c_c^{\sigma-1} \eta^{\sigma-1} > 1$$

It is easy to see that a small η (large externalities) can bring v^* below unity even with transport and communication costs and therefore make the service city a stable equilibrium. Thus, a service city might indeed be a policy option if only the externalities are large enough. However, compared to the pecuniary externalities linking manufactures and consumers as well as manufactures and service firms, the assumption of agglomeration externalities is probably a strong one.

So far the results have been derived from studying certain illustrative situations. To derive the long-run outcome, the model has been solved numerically for a variety of parameter values. To keep things as simple as possible, it has been assumed that transportation costs for industrial goods are large enough to prevent any of the regions from becoming the sole producer of manufacturing goods. With this assumption

From this condition follows that the teleservice scenario cannot constitute a stable situation. It will always be advantageous to satisfy the provinces' demand for manufactures through local production. By relocating to the rural area, manufacturing not only has access to cheaper services but also can pay lower wages which households are willing to accept since no transport costs for agricultural goods accrue.

For completeness consider the decision of a service firm located in the provinces. For such a firm it is profitable to move to the city if the following condition, derived in the appendix, is met:

$$(17) \qquad v = (t_A^{\gamma - 1} t_M^{\gamma})^{\sigma} c_c^{\sigma - 1} > 1.$$

As before, the influence of communication costs on v can be seen easily. First note that without transport costs for agricultural goods it will *always* be profitable for a services firm to move into the city and thus the teleservice scenario cannot constitute an equilibrium. This result is analogous to the previous scenario where with $t_A = 1$ a services firm will never leave the city because it wants to locate close to its customers, the manufactures firms. This desire is increased by a larger c_c, implying a higher v: The larger communication costs are, the tighter is the regional link between manufactures and services.

Last consider the scenario of a 'service city'. All services are concentrated in the city while all manufacturing takes place in the provinces. For manufacturing production to be confined to the provinces, it must be the case that $p_M^* t_M < p_M^{pot}$. In the sam e way as above this condition can be rewritten as

$$(18) \qquad t_M < t_A^{\frac{(1-\gamma)(1-\mu)}{1-(1-\mu)\gamma}} c_c^{-\frac{\mu}{1-(1-\mu)\gamma}}.$$

Thus, if t_A is large enough and c_c is small enough, this equilibrium is stable. The introduction of an information highway even strengthens this equilibrium by reducing communication costs and thus prices of services produced in the city. For these service firms it is profitable to move to the provinces if the following condition (derived in the appendix) is met:

$$(19) \qquad v^* = (t_A^{1-\gamma} t_M^{\gamma})^{\sigma} c_c^{\sigma - 1} > 1$$

Inspection of condition (19) shows that the 'service city' can *never* constitute an equilibrium as long as there are any transport costs. It will always be advantageous for a service producer to relocate to the provinces to be closer to its customers.

To make the relocation profitable, this change in value must be larger than the change in fix costs which are given by w^*/w. Defining a new variable $v^* = V^*/V(w/w^*)$ and using equation (14) we get as condition for a relocation to be profitable

$$(15) \qquad v^* = \left(\frac{w}{w^*}\right)^{\sigma} c_c^{1-\sigma} = (t_A^{1-\gamma} t_M^{-\gamma})^{\sigma} c_c^{1-\sigma} > 1.$$

As long as $v^* < 1$, the service firm will remain in the city. First of all note that a necessary assumption for a profitable relocation are transport costs for agriculture ($t_A > 1$). From equation (14) it is obvious that only with $t_A > 1$ the rural wage can be lower than the urban wage rate. With all manufacturing concentrated in the city, a lower rural wage is the only incentive for a service producer to relocate. From equation (15) the effects of other transport costs on v^* are also easy to see. A larger t_M decreases v^* which is also a wage effect as equation (14) shows: The larger transport costs for manufactures are, the higher must relative rural wages be to compensate agricultural workers for the high costs of satisfying their demand for manufactures. The influence of c_c is also clear: the larger communication costs are, the lower is v^*. Hence, in the metropolis scenario the information highway will decrease the threshold which keeps service firms in the city.

Summarizing both stability conditions for the metropolis scenario leads to the conclusion that the set-up of an information highway might indeed unbalance a situation with all service and industrial production concentrated in the city by loosening the linkage between manufactures and service firms. However, it is not clear from the analytical discussion whether service or manufacturing firms leave the city first. This depends on the parameter values. In any case, if the relocation process has started, it leads to adjustments in all variables of this general equilibrium model. Therefore information about the final general equilibrium outcome can only be obtained from numerical simulations like those conducted below.

We can now ask whether other situations constitute stable locations of economic activity. Let us turn to the teleservice scenario first. We assume that by some historic event all services production is now located in the rural area whereas all manufactures production takes place in the city and the question is whether this can be a stable situation. Manufacturing will remain to be confined to the city if $p_M t_M < p_M^{*pot}$, just as in the previous scenario. In the same way as above this can be transformed to yield

$$(16) \qquad t_M < t_A^{-\frac{(1-\gamma)(1-\mu)}{1-(1-\mu)\gamma}} c_c^{-\frac{\mu}{1-(1-\mu)\gamma}}.$$

$$t_M < \frac{p_M^*}{p_M} = \frac{P_I^{*\mu} w^{*1-\mu} \beta_M}{P_I^{\mu} w^{1-\mu} \beta_M} = \frac{c_c^{\mu} w^{*1-\mu}}{w^{1-\mu}}$$

Making use of equation (11) as well as the derived term for p_M^*/p_M this condition becomes after some rearrangements

$$t_M < t_A^{-\frac{(1-\gamma)(1-\mu)}{1-(1-\mu)\gamma}} c_c^{\frac{\mu}{1-(1+\mu)\gamma}} \tag{13}$$

Obviously, if t_M and t_A are small enough and c_c is large enough, such an equilibrium is sustainable for manufacturing. A decrease in c_c on the other hand can make this situation unstable since the falling communication cost decreases the price of city services in the provinces leading to lower prices for potential manufacturing production there and possibly to a set-up of manufacturing firms in the provinces.

Consider next the service firms. An individual firm will only move to the provinces if wages are lower and if the increase in the value of its sales from lower wages is large enough to offset the decrease caused by falling demand from city manufacturers which is due to higher communication costs c_c. In this case it could make profits by moving. Since service firms mark up prices over marginal cost, they will change the price of their output proportional to the cost change. The latter is only a change in wages which can be derived from equation (11) noting that no service and manufacturing production takes place in the provinces and thus the price of manufactures in the provinces is given as $p_M t_M$.

$$\frac{w^*}{w} = t_A^{\gamma-1} t_M^{\gamma}. \tag{14}$$

Suppose that the number of firms, n, is large. Then the relocation decision of a single service firm does only have a negligible effect on the price index of the service composite. However, since the service produced by the relocated firm now incurrs communication costs, the price of each unit that arrives increases by c_c. The overall price change will affect the number of products sold with an elasticity $-\sigma$ and the firm's value with an elasticity $1-\sigma$. Thus, the relative value of sales of a relocating firm V^*/V is given by

$$\frac{V^*}{V} = \left(\frac{w^*}{w} c_c\right)^{1-\sigma}.$$

II. The Information Highway and Locational Patterns for Firms

The information highway is in this section identified with a decrease in communication costs, which can reflect different phenomena: A financial advice, for example, given bya distant financial services company and delivered by mail, might be somewhat outdated upon arrival. Modern telecommunication technique decreases this delay cost through almost instant delivery. Also a remote consulting firm delivering only a written report gets less of its message accross than one that can discuss critical issues in video conferences. Here also does the information highway decrease costs from lost information. As a last example consider remote diagnosis and troubleshooting of production equipment. This reduces output loss due to a quicker reaction and decreases the diagnosis cost by reducing the need for repair personnel to travel to the defect equipment.

As discussed above, the information highway makes distant production of services less disadvantageous. We will discuss this effect here in the context of a short-run equilibrium by analyzing the stability of three illustrative, albeit somewhat extreme scenarios. The first situation to be discussed is a concentration of manufactures and intermediate producers in the city with only agriculture remaining in the rural region. We call this the ‘metropolis scenario’. Next is a situation where intermediate services are produced in the rural region and manufactures in the city. We call this the ‘teleservice scenario’. The last situation is just the opposite: intermediates are being produced in the city and manufactures in the provinces. This constitutes the ‘service city’.

It is assumed that the economy has arrived at one of these scenarios for reasons not discussed here. Such situation is said to constitute a short-run equilibrium if it is compatible with the regional pattern of manufacturing production as given in equation (4) and if no service firm has an incentive to move to another region. Note that several equilibria are feasible in principle, possibly also with labor and firms split between regions in a different way than discussed here.

Consider first manufacturing in the metropolis scenario. This sector is concentrated in the city and exports to the provinces. Such a situation can only constitute an equilibrium if $p_M t_M < p_M^{*pot}$, i.e., if provincial consumers buy the city goods in spite of transport costs instead of producing the industrial goods for the potential price p_M^{*pot} in their own region.
Using equations (2), (1), and their respective counterparts for the provinces as well as taking into account that no service production takes place in the rural area, this condition can be rewritten as:

$$
(8) \quad y_I = \begin{cases} p_I^{-\sigma} P_I^{\sigma-1+\mu} c_c^{1-\sigma} \mu\beta_M (x_M + y_M) w^{1-\mu} & \text{if } p_M < t_M p_M^*; \\ 0 & \text{otherwise} \end{cases}
$$

$$
x_M = \begin{cases} p_I^{-\sigma} P_I^{*\sigma-1+\mu} c_c^{2(1-\sigma)} \mu\beta_M (x_M^* + y_M^*) w^{*1-\mu} & \text{if } p_M^* < t_M p_M \\ 0 & \text{otherwise} \end{cases}
$$

Labor in both occupations must sum to the total labor force in this region:

$$
(9) \quad L = L_I + L_M
$$

Equations(1)-(9) describe the city's economy and yield a solution conditional on L. The same applies to the provinces except that equation (9) changes to $L^* = L_I^* + L_M^* + L_A^*$ and L_A^* depends on agricultural production: We assume this sector to be perfectly competitive and to be characterized by constant returns to the only input labor. With $(1-\gamma)$ the share of total expenditure in each region going to agriculture and transport cost for agriculture such that $p_A = t_A p_A^*$, the labor force employed in this sector can be derived as

$$
(10) \quad L_A^* = (1-\gamma)L^* + \frac{(1-\gamma)wL}{t_A w^*}.
$$

Perfect labor mobility between regions will assure that real wages in both regions are equal. Using $p_A = t_A p_A^*$, real wage equality implies that

$$
(11) \quad \frac{w}{w^*} = t_A^{1-\gamma} (p_M / p_M^*)^{\gamma}.
$$

Last, labor employed in both regions has to sum up to the total labor force which we normalize to unity:

$$
(12) \quad 1 = L + L^*.
$$

Equations (1) - (9) and their respective counterparts for the provinces describe the equilibrium together with equations (10) - (12). They could – at least in principle – be solved for all variables to yield the long-run equilibrium. However, although the model is fairly simple, it is already too complex to accomplish this. Therefore the model is only solved numerically at the end of the following section to discuss effects of parameter changes like a decrease in communication costs on the long-run outcome. Before turning to these simulations, though, we will follow *Krugman* (1991) in studying some illustrating situations by asking under which conditions these can constitute equilibria and what consequences the introduction of an information highway has on them.

(3) $$wL_M = (1-\mu)p_M(x_M + y_M).$$

Demand functions for the manufactured good produced in the city can be derived from utility maximization as:

(4) $$y_M = \begin{cases} \dfrac{\gamma wL}{p_M} & \text{if } p_M < t_M p_M^* ; \\ 0 & \text{otherwise} \end{cases} \qquad x_M = \begin{cases} \dfrac{\gamma w^* L^*}{t_M p_M} & \text{if } t_M p_M < p_M^* \\ 0 & \text{otherwise.} \end{cases}$$

This discontinuity in demand functions for manufactures is due to the assumptions of transport costs for and homogeneity of manufactured goods produced in either region. As soon as imported goods become cheaper (taking into account transport costs) than those produced in the own region, demand will switch and viceversa.[4] The services sector, which produces the intermediates, consists of a variety of firms producing incompletely substitutable services under monopolistic competition. With fixed cost of service production $\alpha_I > 0$, each firm produces services for the own region (y_I) as well as for export (x_I). Contrary to manufacturing, the services sector uses only labor as input. Total costs for each firm are given by:

$$TC_I = w(\alpha_I + \beta_I(x_I + y_I)).$$

Since labor is perfectly mobile between occupations, the wage rate w must be the same in all occupations within a region. Profit maximizing implies that prices are set as mark-up over marginal cost:

(5) $$p_I(1 - 1/\sigma) = \beta_I w,$$

and a zero profit condition determines the size of service producers as

(6) $$x_I + y_I = (\sigma - 1)\frac{\alpha_I}{\beta_I}.$$

Due to the zero-profit condition all revenue from service production goes to labor as wages:

(7) $$L_I w = np_I(x_I + y_I).$$

The demand for each single variety of the intermediate good can be derived from the cost function of manufacturing firms and the price index for services(1)as:

4. In principle the incontinuities could be avoided by introducing a variety of industrial goods produced under monopolistic competition. However, this only increases the model complexity without yielding any insight beyond that already derived by *Krugman* (1991).

price of manufactures, and U utility. With these preferences, γ is also the share of manufactures in consumers' total expenditure wL. The latter is given by the wage rate w times the total labor force employed in the city, L.

Manufacturing firms produce their output from labor and a variety of differentiated intermediate services. These services are aggregated by a CES technology into a composite with the following price index P_I where $\sigma > 1$ is the elasticity of demand for a single variety:

(1) $$P_I = \left[n p_I^{1-\sigma_I} + n^*(c_c p_I^*)^{1-\sigma_I} \right]^{1/(1-\sigma_I)}$$

The city produces n varieties of services which in equilibrium are sold at the same price p_I. Similarly, the provinces produce n^* varieties and sell them at a price p_I^*. However, using services produced in the other region involves communication costs c_c. These are assumed to take the form of *Samuelson*'s iceberg transportation cost, where the costs are incurred in the produce. Of each information unit brought on its way only a fraction $1/c_c$ arrives. We will assume later that the information highway enters the model via this communication cost by decreasing c_c and therefore making location less relevant.

Each manufacturing firm can produce goods for the same region (y_M) and for export to the other region (x_M), in this case the provinces. However, since the output goods produced in both regions are identical, in equilibrium either both regions produce their own manufactures or one of the regions will become the sole producer of these goods. The latter will take place if transport costs for manufactures t_M (which are also assumed to be of iceberg form) are lower than the price difference between goods manufactured in the city and those produced in the provinces.

Production of industrial goods takes place by combining labor and intermediates using a Cobb-Douglas technique with intermediate share μ, where $0 < \mu < 1$. There are variable costs of production of $\beta_M > 0$ input units per output unit. Then total costs for a firm in this sector are

$$TC_M = P_I^{\mu} w^{1-\mu} \beta_M (x_M + y_M).$$

In equilibrium price equals marginal cost:

(2) $$p_M = \beta_M P_I^{\mu} w^{1-\mu}.$$

Since factors are paid their marginal product, $(1-\mu)$ of the revenue goes to labor employed in this sector:

highway, the model is extended in a second step to allow for the case where service workers can use the information infrastructure to work from their homes in a distant firm. This is the situation typically understood as teleworking. The model modification thus captures the consequences of the information highway for the location of households.

The paper is organized as follows: In the first section the model's structure is derived. In section II we analyze feasibility and stability of some illustrative short-run equilibria for the location of firms when an information highway is being build and discuss long-run effects by means of numerical simulations. Section III derives the spatial consequences for household location when teleworking is possible. Section IVconcludes.

I. The Model

The model, which is based on the monopolistic competition framework proposed by *Dixit* and *Stiglitz* (1977), is a variant of the economic geography models introduced by *Krugman* (1991) and later extended for example by *Krugman* and *Venables* (1995). Within this framework our economy consists of two regions: an urban region – the city – and a rural region – the provinces – which spans the remainder of the economy. In both regions two sorts of goods can be produced: identical manufactures or industrial goods, which are produced from labor and a set of intermediate goods with constant returns, as well as these intermediate goods, which are produced under monopolistic competition from labor. The intermediate goods are thought of as describing production services like consulting, accounting, research, information services, etc. A third good, agriculture, is produced only from labor with constant returns. We assume that an agricultural sector only exists in the provinces, not in the city. Labor is perfectly mobile between all regions and occupations. In most of the paper it is assumed that workers live where they work which excludes commuting or teleworking. We will relax this assumption lateron for a short discussion of possible consequences from teleworking.

To keep the model as simple as possible, production technologies and preferences are assumed to be the same in the urban and rural region. For ease of exposition only the city is described wherever possible below. Analogous conditions hold for the provinces. The three sectors agriculture, manufactures, and intermediates are denoted by subscripts *A*, *M*, and *I*, respectively. Where present, rural variables are denoted by an asterisk.

The city is populated by representative consumers receiving only labor income. Their preferences for agricultural and industrial goods are given by a Cobb-Douglas expenditure function $p_A^{1-\gamma} p_M^{\gamma} U$ with $0 < \gamma < 1$ where p_A is the price of agriculture, p_M the influences on traffic and transportation. When these technologies emerged in the 1970s, they were seen as a possible substitute for commuting and business traffic, promising a reduction of congestion problems.[2] Thus, a large part of the literature is concerned with teleworking and video conferencing. The empirical evidence about these technologies, however, is mixed. The demand for teleworking as well as video conferencing has been rather low so far, partly due to unfavorable staff attitudes (cf. *Bertuglia* and *Occelli*, 1995).

However, from *Lenin*'s phantasies to the current discussion about Berlin the location decisions of firms and less those of households are the focus of attention. People like *McLuhan* and *Ungers* argue that information technology leads to a change in the *location of economic activity*, bringing to an end the concentration of this activity in large cities. But this is only one one view: Quite contrary to this position, politicians, for example in Berlin, propagate the ideal of a 'service city' as goal of economic policy, also made possible by the advances in information and communication technologies. By this they mean a city dominated by a concentration of service sector activity, having in mind the concentration of financial services in London or New York or other (well-paid) service activities which serve as input for industrial or other service production. These opposing views about the future of cities motivate this paper.

The focus on services as an input to industrial production is reflected in the model presented in the subsequent sections. The basic model describes a *Krugman* (1991) type economy consisting of two regions, city and provinces, with two (main) sectors of production: manufacturing, which produces goods for household consumption, and services, which are inputs for manufacturing. These services form the main focus of the analysis as we will identify the information highway with a decrease in communication and coordiniation costs involved with distant service production. Thus, the information highway has the effect that distance between service producers and their customers becomes less relevant. This is the main effect to be discussed in this paper.[3] In addition, since 'teleworking' is discussed quite heavily in connection with the information

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2. This reminds one of the early days of the PC, when it was commonly assumed that computer technology would lead to the paper-less office.
3. While sharing the motivation, this paper differs considerably from *Gaspar*'s and *Glaeser*'s (1996) recent discussion of „Information Technology and the Future of Cities“. In their model cities are a means of reducing the fixed costs involved in face-to-face interactions. Improvements in telecommunications technology lead to substitution of face-to-face by electronic interaction on the one hand and to an increase in frequency of contact between individuals possibly resulting in more face-to-face interactions. The overall result then depends on the question which effect dominates.

Throughout the twentieth century there have been recurrent phases where improvements in information technology were thought to bring about the end of the city as a geographical agglomeration of people and firms. In the 1920s Russian constructivists demanded the dissolution of cities like Moscow as “the modern city is a product of mercantile society and will die together with it.” (*Miliutin*, 1930, 56) Cities and countries should merge through an extensive network of linear settlements, made possible by modern technology as envisioned by *Lenin*: “At the present time, when the transmission of electrical energy over long distances is possible and when the technology of transportation is improved, there are absolutely no technical obstacles to resettling the population more or less evenly over the entire country, and still taking advantage of the treasure houses science and art which have for centuries accumulated in only a few centers.”[1]

While these socialist phantasies are planning problems, later prophets regarded the dissolution of cities as something to happen even without government intervention: In the technology-obedient 1960s *Marshall McLuhan* prophesied the famous ‘escape from New York’ – also made possible by modern technology. Nowerdays, we seem to be in one of these phases again: The German architect *Oswald Matthias Ungers* regards his own work as a “desperate attempt to resurrect urban places” at the “end of the technological century with super bits and bytes, information highway, Internet, and CD-ROM”. (*Ungers*, 1995). Meanwhile several Cassandras warn that the center of Berlin, which is currently being filled with square miles of office space in a construction boom as heavy as last seen in the 1870s, will be a ghost town after completion – become obsolete by e-mail, video conferences, and teleworking.

So far the hype. Within economics the spatial consequences of technological advances in telecommunications and computing have so far found less interest, and if so mostly at the level of economic and regional policy (e.g., *OECD*, 1992) which led the OECD to the conclusion that „nobody knows how information and communication technologies will influence the way people and firms use space.“ (*De Michelis*, 1995, 12) This is rather astonishing since the adoption of technologies as well as the choice of location follows largely economic incentives. Availability of new technologies per se does not necessarily have economic and locational effects.

Furthermore, most of the economic work on possible consequences from new information and communication technologies focuses on a single aspect, namely on their

1. Cited according to *Miliutin* (1930, 61).

The “Information Highway” and the Location of Economic Activity

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This paper studies possible consequences from building an “information highway” for the location of firms and households in the context of a two-region, three-good model of economic geography. The advancements in information and communication technology are identified with a decrease in transportation costs for intermediate services on the one hand and with a decrease in the costs of teleworking for households on the other hand. The stability of three situations is investigated: all production in the city; manufacturing in the city and services in the rural region; manufacturing in the rural region and services in the city (service city). While the first situation can constitute a stable equilibrium, the second cannot and the third is only feasible if additional locational externalities exist for services in the city. Even then the service city can become a “virtual city“ if costs of teleworking decrease enough to encourage households to move to the rural region and telework.

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