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Kristof Dascher

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Kristof Dascher, University College Dublin

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Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Trade, FDI and Congestion – the Small and very Open Economy*

Typically, a small and open economy trades goods at given world prices. Here, we present a model of a very open small economy, where capital and labour are internationally mobile, too. When investing into infrastructure, the economy's government attracts not only mobile capital but mobile labour, too. These capital and labour inflows into the economy reinforce each other. They contribute to rising welfare for land-owning indigenous households. But all potential benefits for land-renting immigrant households are capitalized into higher land rents. - The Paper is also an attempt to give an account of the recent economic boom in Ireland.

JEL Classification: F11, F23 and R23

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Kristof Dascher
Department of Economics
University College Dublin
Belfield
Dublin 4
IRELAND
Tel: 00 353 1 706 8239
Fax: 00 353 1 283 0068
Email: Dascher@euv-frankfurt-o.de

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NON-TECHNICAL SUMMARY

Recent years have witnessed an impressive inflow of foreign direct investment (FDI) into Ireland. This Paper asks three questions: (1) First, what is the impact of the FDI inflow on the Irish factor endowment? (2) Second, how are the benefits of FDI distributed among Irish households? (3) And finally, can we, from looking at this seemingly very special case, learn something about FDI at large?

We discuss these three issues in turn. As a starting point, the following imaginary *headlines* might be seen as one possible account of how the FDI inflow has impacted on the Irish economy:

“Investment into Irish infrastructure has increased the return to capital in Ireland, thereby attracting FDI. The infrastructure investment as well as the FDI inflows have made labour productivity rise, eventually leading to rising wages. Given the international mobility of Irish (expatriate) workers, higher wages have also induced remigration. Finally, higher wages together with remigration have led to rising land rents.”

Brief as they are, these headlines capture two important features of the Irish boom. First, they point to the role of **international labour mobility**. Hence, in the Paper’s model, not only capital is considered to be internationally mobile – labour is, too. And second, these headlines point to the role of rising land rents. In Irish reality (and in the Paper), rising land rents affect the distribution of benefits from FDI. Clearly, landowners must benefit, while land-renters must suffer. Thus, in the model the assumption of an inelastic land supply introduces **redistribution** of benefits from FDI.

Brief as they are, these headlines also have two shortcomings that have to be addressed in more detail in the Paper. Their first shortcoming is their neglect of the mutual interaction between FDI and immigration. Not only might FDI fuel immigration, but immigration might also fuel FDI. On entirely neoclassical grounds, the Paper’s model shows that capital inflows and labour inflows in response to an increase in Irish infrastructure **reinforce** each other, creating an ‘agglomeration’. This notion of agglomeration immediately carries over to the headlines’ second shortcoming: While the headlines do inform about the impact of factor inflows on land rents, they say nothing on how rising land rents affect factor inflows. But surely rising land rents must act as a ‘brake’ to further immigration. Moreover, any consistent model must explain why mutually reinforcing factor inflows eventually die down instead of building up to an ever-increasing agglomeration. In the model, this explanation is provided by **congestion** operating through the land market.

So there is a close connection between factor inflows and land rents. On the one hand, higher land rents slow down factor inflows. On the other hand,

factor inflows drive up land rents. It is worthwhile to explore this last point a bit further: if we assume that immigrants into Ireland do not own Irish land then these immigrants have to use part of their income gain (from participating in a booming economy) for rent expenditure. Surely any increase in income will in the short run improve these immigrants' wellbeing. But over time this all too visible improvement should attract more immigrants. Thus, in the long run immigration into Ireland inevitably persists until all income gains for non-land-owning households are eroded by higher land rents.

One could say: income benefits for non-land-owning households completely capitalize into land rents. This **capitalization** result follows directly from our assumption of perfect international labour mobility. In the Paper, we interpret capitalization in two ways: first, capitalization reflects redistribution from non-land-owning households to land-owning households. Second, a measure of capitalization may, if adequately adjusted, also reflect the overall benefits flowing from the initial infrastructure investment. In that sense, land rents might provide an interesting '**hedonic benefit** measure' of overall benefits.

At this point we should look at the model's set-up: Labour and capital are internationally mobile. There is trade in goods in order to reflect the Irish economy's openness. Also, Ireland is seen as a *small* open economy: prices for tradable goods and prices for international factors are determined elsewhere and do not react to domestic conditions. Finally, households demand land to live on. Since land supply is assumed inelastic, any changes in land demand quickly translate into land rent changes. One might call this model economy a **very open small economy** (as is done in the Paper's title). But note that one could equally well describe this model economy using the concept of the '**open city**' familiar from *urban economics*. Open cities are characterized by an exogenous level of well being for city households because any change in income is immediately offset by the effect of corresponding inflows or outflows of households on labour productivity, land rents, or yet different types of congestion.

So the scenarios analysed in the Paper may not just reflect the Irish case. They may also apply to any open city experiencing large inflows of capital. Not only would we expect to see inflows of capital that are reinforced by inflows of labour. We would also expect to see capitalization of benefits from FDI into land rents. Open cities with inflows of FDI, then, offer a potential route of measuring benefits from FDI to the 'domestic economy'.

1. Introduction

This paper is an attempt to capture a number of typical features of the “very open small economy”. Typically, being *open* implies that an economy freely trades goods with other countries in the rest of the world. Sometimes, being open also allows for the international mobility of capital. In this paper, being *very open* implies that not only goods and capital can freely flow in or leave the economy - labor can too. Being *very open and small*, then, implies that the prices of tradable goods as well as the prices of the two mobile factors are determined in world markets. They are not subject to changes in local supply and demand decisions. In this context, we will ask which additional insights the “very open small economy”-assumption can produce over and above the usual “open small economy”-assumption. To this end, we will often compare the very open small economy with the merely open small economy.

The paper is also an attempt to bind together some stylized facts of the recent Irish economic success. The assumptions of the model presented in the following sections are in many ways specific to Ireland. Interestingly, the model generates a number of results that closely resemble the Irish growth performance, also. Thus “calibrated”, the model offers predictions on the impact of an adverse shock that has not been encountered to date. But, of course, we could also ask whether the results derived in this paper also apply to other economies - such as Singapore, Hong Kong, or Luxemburg - which by our definition are very open and small, or whether, more generally yet, they even apply to regions or *cities*.

The paper draws on earlier work in international, regional and urban economics. In using duality theory to describe general equilibrium in models of trade, the paper builds on the methodology set out by Dixit and Norman (1980). In letting government provide a public input to the private production sector within the Dixit/Norman-framework, we borrow an idea explored by Kanemoto (1980) and Michael/Hatzipanayotou (1996). In allowing capital mobility alongside trade in goods and in assuming the existence of specific factors in at least some of the industries, the paper is also closely related to Neary (1995). Finally, the explicit treatment of the small economy’s land market not only adds a non-tradable good to the economy and will thereby, given an inelastic supply of land, cause congestion. It also embraces a central

theme in the urban economics of the “open city”. There, if migration is costless, the benefits related to the public input may in the extreme case be completely capitalized into land rents.

The paper is in seven parts. The second section sets up the assumptions of the model and presents the agents’ behavioral functions. The third section discusses the general equilibrium of the model. In the fourth section, we focus on the consequences of public infrastructure investment. In section 5, we discuss the corresponding welfare implications. The sixth section has a case study that matches the model’s central assumptions and outcomes with stylized facts of the recent Irish economic success (“Celtic Tiger”). Section 7 concludes.

2. The Model

In what follows, we focus on a “very open small economy”, or, equivalently, on a “region”. Sometimes, we will refer to this very open small economy more briefly as “Island” (I). Households in Island will also be “indigenous households”. Besides Island, a larger region exists which we will call “Mainland” (M). To any other parts of the world besides Island and Mainland we will refer as the “Rest of the World” and to their households as “foreign households”. In terms of population size, Mainland is very much larger than Island, while the Rest of the World is again very much larger than Mainland.

By focusing on a “small and very open economy”, we not only invoke the standard small and open economy properties of (i) exogenous world prices for tradable goods and (ii) an exogenous return to internationally mobile capital. We also allow (iii) labor to migrate between Island and Mainland, with the reservation utility level determined in Mainland and unaffected by Island’s actions. Moreover and (iv), we assume that migration from Mainland to Island affects the prices of non-tradables in Island while it does not change any non-tradable’s price in Mainland. Hence, it is Island’s smallness that allows us to focus on Island’s economy without having to worry about potential repercussions from Mainland or the Rest of the World. And it is Island’s openness in

terms of goods *and* factor mobility that creates an overlap between regional economics and traditional international economics.²

Island's production takes place within three distinct sectors of the economy. First, there is a tradable goods sector that consists of two industries, electronic consumer goods E and food F . While each industry employs an industry-specific type of capital, it also relies on labor as a second input. As is typical of such a model of "specific factors", only labor can move from one industry to the other. It is in this tradable goods sector where the economy's properties of being small as well as very open most visibly combine.

However, the degree of mobility varies by factor. Capital specific to electronics K is perfectly mobile, moving costlessly to whichever region offers the highest return. Labor L is somewhat less mobile, being allowed to move only between Island and Mainland. Labor, too, changes location costlessly. The part of the labor force L that is indigenous to Island will be denoted by I , while the number of Mainland immigrants in Island is M . Thus, $L \equiv M + I$.³ Finally, capital specific to food processing C is assumed not mobile at all.⁴ Usually, we will refer to mobile "electronics capital" K simply as "capital" as opposed to immobile "food capital" C .

Island's second sector is the non-tradables sector. In this sector, land T is supplied to whoever is prepared to pay the going price or "land rent" q . Thus, land as the nontradable "good" is not actually produced but already available for use. -

Government is Island's third sector. Here, land is used to produce a public input g which benefits all firms' productivity (but not households' utility).⁵ In a very simple fashion, we assume that it takes one unit of land to produce one unit of output.

² Of course, this theme goes back at least to Krugman (1991) who insists that the distinction between countries and regions becomes increasingly meaningless with more factor mobility.

³ This choice of terminology might lead to misunderstandings. So, early on, it should be stressed that "immigrants" are "incumbent immigrants", i.e. they are the *stock* of immigrants already in Island and not an inflow of immigrants.

⁴ The assumption of capital mobility differing by sector follows Neary (1995).

⁵ This intermediate good function is why the public output g also is a public "input". Kanemoto (1980) and Michael/Hatzipanayotou (1996) have a general treatment of a public input within the Dixit/Norman-framework that includes the very special case built into this model.

Beyond land, no other inputs are needed. Examples of this public input g might be industrial estates.⁶

Let electronics output E be produced according to the neoclassical production function $g^E(K, L_E)$ where K is the quantity of specific capital in electronics and L_E is the amount of labor employed in electronics. Food production is by the neoclassical production function $g^F(C, L - L_E)$. Here, C is the specific capital in the food industry and $L - L_E$ is the food industry's employment. Obviously the public input serves both industries equally well. Infrastructure services g provided by the industrial estates enter into electronics and food production much like a product augmenting technological externality (see Dixit/Norman, 1980). Note that a change in g on its own does not affect the allocation of labor across the two industries.⁷ - Each of the two production functions are assumed to exhibit constant returns to scale with respect to its two inputs. The exogenous tradable goods prices we will indicate by the price vector $p = (p_E, p_F)$.

Note that the tradable sector's revenue (or GDP-) function is simpler than it might seem. While there are three different sectors, government and the nontradables sector use an input (land) that is never employed in the tradables sector. Conversely, the tradables sector uses three inputs (labor and the two industry specific types of capital) that are employed neither in the government sector nor in the nontradables sector. Hence, whatever the output prices p and q , there are no possibilities of factor substitution between the government sector and the nontradables sector on the one hand and the tradables sector on the other hand. Maximum revenue in the nontradables sector is simply given by Tq . Maximum revenue in the tradables sector at given output prices, factor endowments and at an exogenous level of the public input is given by the

⁶ It is tempting to think of the public input as transportation infrastructure - roads being the most prominent use of urban land for public good purposes. However, this model's economy does not have an internal urban structure so that we have to refrain from this interpretation.

⁷ In particular, we assume that there is no "targeting" of the electronics industry. Discrimination against the food industry, e.g. by providing club good type public inputs, would strengthen the model's results, but is not needed in what follows.

revenue function $r(p, K, C, L, \mathbf{g})$. This revenue function, as is clear from the discussion above, depends neither on the land rent q nor on the land area T .

As the capital stock specific to the food industry C has earlier been assumed immobile, it will not vary throughout the model. Hence, we drop C from the notation of the revenue function. By the envelope theorem, the revenue function has the property that its partial derivatives $r_K(p, K, L, \mathbf{g})$ and $r_L(p, K, L, \mathbf{g})$ equal the value marginal products of capital (i.e., electronics capital) and labor, respectively, evaluated at the optimum allocation of labor $(L_E, L - L_E)$ to the two industries. These value marginal products can also be interpreted as the return to capital and as the wage rate, respectively, in competitive equilibrium.

Later on, it will prove interesting to know the precise reactions of these factor returns to changes in the total stock of capital or labor. After all, Island's stocks of capital and labor are liable to change due to their mobility. But these reactions are standard in the specific factors model and can easily be read off a Ricardo-Viner-type diagram.⁸ An inflow of labor depresses the wage and drives up the capital rental, hence

$r_{LL}(p, K, L, \mathbf{g}) < 0$ and $r_{KL}(p, K, L, \mathbf{g}) > 0$. An inflow of capital depresses the capital rental and drives up the wage rate, so that $r_{KK}(p, K, L, \mathbf{g}) < 0$ and $r_{LK}(p, K, L, \mathbf{g}) > 0$.

Leaving the original allocation of labor unaffected, a higher level of \mathbf{g} works exactly like a simultaneous increase of both prices p_E and p_F by increasing the wage rate as well as both capital rentals, i.e. in particular $r_{L\mathbf{g}}(p, K, L, \mathbf{g}) > 0$ and

$r_{K\mathbf{g}}(p, K, L, \mathbf{g}) > 0$.

3. General Equilibrium

As equilibrium prices p for the two tradable goods are exogenous throughout this paper, we can ignore the two corresponding equilibrium equations. We let food be the numeraire, i.e. $p_F \equiv 1$. Since the exogenous terms of trade p_E will not vary throughout what follows, we drop the price vector p from the notation of the revenue

⁸ For this type of diagram see, for example, Dixit/Norman (1980, p. 40-43). For the following second-order derivatives see the Appendix for more details.

function. Equilibrium in Island's economy is described by the following set of six equations.

$$(1) \quad e(q, u^i) = r_L(K, L, \mathbf{g}) + q - t \quad (i = 1, \dots, I)$$

$$(2) \quad e(q, u^m) = r_L(K, L, \mathbf{g}) - t \quad (m = 1, \dots, M)$$

$$(3) \quad T = Ie_q(q, u^i) + Me_q(q, u^m) + \mathbf{g}$$

$$(4) \quad r_K(K, L, \mathbf{g}) = \mathbf{r}$$

$$(5) \quad u^m = \bar{u}$$

$$(6) \quad t = \mathbf{g}l/L$$

Equation (1) gives the budget constraint for each of the I indigenous households. Preferences are identical and are represented by the common expenditure function $e(q, u^i)$. Indigenous households derive utility from living on a parcel of Island's land as well as from consuming the two tradable goods, food and electronic consumer goods. Each indigenous household inelastically supplies one unit of labor to the tradable goods sector, receiving his value marginal product $r_L(K, L, \mathbf{g})$ in turn. Moreover, each indigenous household owns one unit of land. Selling this unit, he receives a land rent of q . Net total income, then, is land income plus labor income minus taxes. - With monotonous preferences, this net total income is exhausted by expenditure on tradable and nontradable goods.

Equation (2) is the typical budget constraint for each of the M households that in the past have immigrated into Island. And it also is the budget constraint for any newly arriving immigrant households ΔM . Immigrants' preferences are identical to indigenous households' preferences. Also, immigrants are similar to indigenous households in that they earn income from supplying labor $r_L(K, L, \mathbf{g})$ and in that they

have to pay the same taxes t . But since immigrants are not indigenous to Island, they do not receive any land income.

This description of an immigrant household is very much aimed at “remigrating expatriates”, i.e. formerly indigenous households that in the past have migrated to Mainland and now consider coming back to Island. Naturally, then, do they have the same preferences as indigenous households. Also, it might seem very reasonable to let both types of households have different land endowments. After all, households that had left Island for Mainland in the past would likely have been poorer than households that stayed. - Although this immigrant concept excludes immigrants with different preferences or types of income, it is not as restrictive as it seems. In a broader sense, this concept can also reasonably capture immigration from Island’s “rural areas” or, more relevant even, the idea that formerly unemployed rejoin the labor force.⁹

Equation (3) is the equilibrium condition for Island’s land market. Each of the I indigenous households supplies one unit of land, giving rise to an aggregate land supply T just equal to I . Demand for land comes from indigenous households, immigrant households and government. By Shepard’s Lemma, indigenous and immigrant households’ (Hicksian) individual demand functions are the derivatives of the expenditure functions with respect to the land rent. Hence we have $e_q(q, u^i)$ and $e_q(q, u^m)$, respectively. Due to its simple production function, the government’s inelastic demand for land is simply equivalent to the amount of the public input g that it intends to provide. In that sense, land not only is a consumption good for households but serves as an intermediate good for the tradable goods sector, too.

In the very open small economy, equations (4) and (5) are no-migration-conditions for the two mobile factors, that is, for capital K and labor L . In (4), Island’s rate of return to capital must in equilibrium equal the exogenous rate of return r prevailing in Mainland and the Rest of the World. In equilibrium, similar conditions must surely apply to the other mobile factor, labor. First, we look at Mainland households. Let u^m

be the utility that an immigrant from Mainland could potentially enjoy in Island and let \bar{u} be his reservation level of utility in Mainland. Then two constellations are consistent with no migration from Mainland to Island. Either we observe $M = 0$ because $u^m < \bar{u}$ or, alternatively, we have $M > 0$ so that $u^m = \bar{u}$. In (5), we effectively assume that the latter constellation applies in the initial equilibrium. Mainland households have migrated to Island until immigrant households' utility has been driven down to the reservation level of utility. - A very similar discussion applies to the migration choices of those I households that are indigenous to Island. Only, in their case we assume that their level of utility if they migrated to Mainland would be *lower* than the level u^i that they can secure for themselves by staying in Island.¹⁰

Finally, equation (6) defines the tax t as the ratio of the cost of providing the government-chosen level of the public input, qg , to the total Island population, L . In section 4, we will analyze a shock that benefits indigenous households. Surely, then, the number of indigenous households I will not change. There we will also analyze a shock that hurts indigenous households - as well as immigrants. There we suggest that immigrants are the only ones to leave by assuming that u^i is much larger than \bar{u} in the initial equilibrium. Hence, the stock of indigenous households I will not change throughout the paper. In equations (1) to (6), then, the *endogenous* variables are Island's stock of capital K and its number of immigrants M , its land rent q , the levels of utility for indigenous and immigrant households, u^i and u^m , respectively, and the level of the lump-sum income tax t .

Before turning to comparative statics, we have to address a peculiarity of the model. When adding up, it becomes clear that not all income generated in the Island-economy is accounted for in the I budget equations in (1) and the M budget equations in (2). That is, neither income from capital nor income from food capital show up as income to indigenous or immigrant households. This is for two very different reasons. One reason is that one would like to think of all capital being imported from the Rest of the

⁹ The interpretation of \bar{u} would have to change accordingly. For instance, in the case of an unemployed \bar{u} would now mean the level of unemployment benefits.

¹⁰ While not necessary, it seems plausible to restrict migration to one direction.

World, so that, accordingly, all income accruing to capital will flow out of the economy. Then (i) complete foreign ownership of the specific factor in the electronics industry, together with (ii) that factor's perfect international mobility make the electronics industry Island's "Foreign-Direct-Investment (FDI)"-industry.

The other reason for unaccounted income in (1) and (2) is that, somewhat inadequately and merely for reasons of tractability, all food capital is assumed to be foreign-owned, too. This assumption serves to restrict heterogeneity in net income between indigenous and immigrant households to the difference in land ownership, nothing more. - It follows, then, that Island's capital income from the electronics industry and food capital income from the food industry is exclusively spent on either tradable goods or on the Rest of the World's non-tradable goods. After all, foreign households would, as non-residents, hardly consume Island's - non tradable - land area.¹¹

Taken together and viewed from Island's perspective, we have an outflow of capital income plus food capital income to foreign households. By definition, any such net outflow of income lets gross national product (GNP) fall short of gross domestic product (GDP), i.e. $GNP < GDP$. By Walras Law, any such net outflow must result in a current account *surplus*. Either in electronics, or in food, or in both industries, will Islanders need to consume less than they produce.

Substituting (5) and (6) into (1) to (3) and recalling that T simply equals I yields the more compact system of equilibrium equations (7) to (10). Here, the remaining endogenous variables are K, M, q and u^i .

$$(7) \quad e(q, u^i) = r_L(K, L, \mathbf{g}) + q - \frac{q\mathbf{g}}{L} \quad (i = 1, \dots, I)$$

$$(8) \quad e(q, \bar{u}) = r_L(K, L, \mathbf{g}) - \frac{q\mathbf{g}}{L} \quad (m = 1, \dots, M)$$

¹¹ We hereby overlook the maybe important issue of "tourism", or foreign direct investment into real estate.

$$(9) \quad I = Ie_q(q, u^i) + Me_q(q, \bar{u}) + \mathbf{g}$$

$$(10) \quad r_k(K, L, \mathbf{g}) = \mathbf{r}$$

Before examining comparative statics behavior of the equilibrium, it is instructive to look at equations (7)-(10) one by one. To start, from inspection of the land market equilibrium in (9), we can see that in the presence of any positive, inelastic government demand for land (i.e. $\mathbf{g} > 0$), indigenous household consumption of land $e_q(q, u^i)$ must be smaller than its land endowment of one unit. Put differently, each indigenous household is a *net seller* of land.

(i) For ease of notation, we drop the arguments here and identify indigenous and immigrant expenditure functions and their derivatives by the index i for indigenous households and m for immigrant households. Then, a “marginal” increase of q by one pound increases the indigenous household’s expenditure on land by roughly e_q^i pounds. And his taxes increase by \mathbf{g}/L pounds. On the other hand, income from selling land rises by one pound. The net effect on i ’s income then is $1 - e_q^i - \mathbf{g}/L$. Reverting back to the equilibrium condition in (9), we see that this expression is positive if $M > 0$ - which we have assumed above. We can conclude that any increase in the land rent must unambiguously benefit all indigenous households, given their net selling position vis-à-vis immigrants and government.

(ii) For a moment, let us turn to the immigrant household. It is important to notice that we have inserted the no-labor-migration condition into his budget constraint (8). This implies that any increase in q *must* in some way be compensated as to keep the immigrant’s utility u^m in line with \bar{u} . The increase in q increases the immigrant’s expenditure by $e_q^m + \mathbf{g}/L$. In contrast to the indigenous household, no positive effect shows up as the immigrant does not own land. From (8), accordingly, we can conclude then that the immigrant’s net wage $r_L - \mathbf{t}$ must c.p. rise (for whichever reasons) by just the damage $e_q^m + \mathbf{g}/L$ inflicted on him by the land rent increase.

We can now revisit the indigenous household. Any increase in the net wage $r_L - t$ due to the no-labor-migration-condition benefits both types of households! The net impact of a land rent increase on the indigenous household, then, is to increase his income (i) by the immediate impact $1 - e_q^i - g/L$. Moreover and second (ii), there is an indirect impact via the net wage that increases his income by $e_q^m + g/L$. The total expansion of his income then is $1 + e_q^m - e_q^i$. More formally, we subtract (8) from (7) to get $e^i - e^m = q$.¹² Totally differentiating gives

$$(11) \quad du^i = \frac{1}{e_u^i} [e_q^m - (e_q^i - 1)] dq$$

Basically, this is just the result we have found above. As the expression in square brackets is always positive, a higher land rent in Island unambiguously increases indigenous utility. This reflects the impact of the higher land rent as well as the role of the no-labor-migration condition.

Returning to the land market equilibrium, we find that the reaction of the land rent to increasing immigration is ambiguous. To explore why, we look at the land demand functions of the two types of households in (9). First, immigrant households' demand is clearly downward sloping in the land rent. But second, indigenous households' demand might be upward sloping in the land rent. This is because according to (11) an increase in the land rent improves indigenous income and, thus, utility. This "income effect" runs counter to the standard substitution effect. If the former dominates the latter, then indigenous households' land demand will increase with the land rent. In this scenario, then, an excess demand of land brought about by immigration would possibly only vanish if the land rent *decreased*.

To sort out these effects, we differentiate (9) totally and insert (11). After rearranging, we get

$$(12) \quad dq = -\frac{(e_q^m dM + dg)}{\mathbf{d}} \quad \text{where} \quad \mathbf{d} \equiv (Ie_{qq}^i + Me_{qq}^m) + \frac{e_{qu}^i}{e_u^i} I(e_q^m + 1 - e_q^i)$$

In the definition of \mathbf{d} in (12), the expression in the first pair of brackets corresponds to the aggregate substitution effect while the expression in the second pair of brackets is the now familiar income effect per indigenous household, multiplied by their total number I . This aggregate income effect translates into demand changes through e_{qu}^i/e_u^i , which actually is the propensity to consume land given a marginal increase in income.¹³ - In what follows, we will make the assumption that $\mathbf{d} < 0$ holds, i.e. the aggregate substitution effect dominates the aggregate income effect. This is a condition for the Walrasian *stability* of the land market equilibrium because it implies that the aggregate Marshallian demand for land is inversely related to the land rent. As is clear from (12), such $\mathbf{d} < 0$ implies that an increase in immigrant numbers or a higher level of the public input will unambiguously increase the land rent.¹⁴

Next, we turn to (8) which, as stressed earlier, after the substitution of \bar{u} for u^m represents the new *no-labor-migration-condition*. Equation (8) gives combinations of electronics capital K and total labor $L = M + I$ that keep immigrant utility at the reservation level \bar{u} . On the one hand, an increase of immigrants M has the following three (direct and indirect) negative effects on the “incumbent” immigrant’s well-being: Directly, an increase of labor depresses labor income r_L . Indirectly, and from (12), an increase of M drives up the land rent. This not only renders the given level of the public input more expensive, hence tending to increase taxes. It also raises the immigrant’s expenditures on land. - On the other hand, and as the only positive effect

¹² With a positive land rent, indigenous utility must always be higher than immigrant utility. This is because the indirect utility function increases with higher income.

¹³ Note that the expenditure function is the inverse of the indirect utility function. Then, $1/e_u^i$ simply is the extra utility from a marginal increase in income. This extra utility translates via e_{qu}^i into a change of Hicksian demand.

¹⁴ The expression defined by \mathbf{d} corresponds to similar expressions in international trade theory. See, as one example, Dixit/Norman (1980, p. 131). The important difference is, though, that in trade theory the income effect comes from (international) redistribution via changing terms of trade while here (intranational) redistribution is through the land market.

of increasing immigration, taxes tend to fall as the cost of the public input can be spread over a larger base of tax payers (an “agglomeration economy”).

Analytically, we find these results by differentiating (8) totally, substituting dq from (12), and setting $d\mathbf{g} = 0$:

$$(13) \quad \frac{dK}{dM} = -\frac{r_{LL}}{r_{LK}} + \frac{1}{r_{LK}} \left[\left(-\frac{e_q^m}{\mathbf{d}} \right) \left(e_q^m + \frac{\mathbf{g}}{L} \right) - \frac{q\mathbf{g}}{L^2} \right] \quad \text{“Slope of MM-locus”}$$

The first term on the right side of (13) is positive and gives the inflow of electronics capital needed to “compensate incumbent immigrants for the wage compressing effect of the immigration of one additional immigrant”. The term in square brackets collects the various remaining effects. Among these, the two effects relating to a more crowded land market call for an increase of electronics capital.

Throughout the remainder of the paper, we make the central *Stability Assumption* that these two land-market-related crowding effects dominate the “agglomeration economy” just mentioned.¹⁵ Hence, the sum in square brackets on the right side of (13) will be positive. In particular, if the no-labor-migration-condition (8) is to hold, then an increasing number of immigrants in Island has to be countered by an *increasing* stock of electronics capital in Island. Hence, if we represented (8) by means of an equilibrium locus “MM” in a diagram with capital K and immigrants M on the axes, this locus would have to be upward sloping.

While (7) to (9) give one equilibrium locus, equation (10) as the *no-capital-migration-condition* gives the other. This locus “KK” indicates the set of combinations of capital and immigrated households that keep Island’s return to capital at the level of its

¹⁵ Note that this Stability Assumption implies our earlier assumption that the land market is Walras-stable. Only if \mathbf{d} is negative, can the expression in square brackets possibly be positive. - Without the Stability Assumption assumption, the general equilibrium in the Island economy might not be stable with respect to changes in factor stocks. This, then, reveals the crucial role of the land market in the model. Without the dampening impact of the land market, any deviation from equilibrium could possibly lead to ever increasing inflows of labor and capital (which would be difficult to reconcile with empirical work).

corresponding world rate of return r . From inspection, this locus must be upward sloping, too. Totally differentiating (10) leads to the slope of the KK-locus:

$$(14) \quad \frac{dK}{dM} = -\frac{r_{KL}}{r_{KK}} > 0 \quad \text{“Slope of KK-locus”}$$

Before drawing both loci into a diagram, we yet need to compare their slopes. Given our Stability Assumption, a *sufficient* condition for MM to have a larger slope than KK is:

$$(15) \quad -\frac{r_{LL}}{r_{LK}} \geq -\frac{r_{KL}}{r_{KK}}$$

Using a particular property of the specific factors model, the Appendix shows that (15) actually always holds with *equality*! Hence, MM actually *is* steeper than KK, as sketched in Figure 1. Note, that the left hand side of (15) is the increase in capital, in response to an increase of labor, that is needed in order to keep the wage r_L constant. Similarly, the right hand side of (15) is the extra capital, in response to an increase of labor, that is needed in order to keep the capital rental r_K constant. Furthermore, both wage and rental only depend on the ratio of labor to capital within the electronics sector.¹⁶ Hence, any joint inflow of labor and capital into the economy that should leave the wage unaffected must leave this ratio constant. But, if the ratio of labor to capital in the electronics sector remains constant as not to change the wage, then the return to capital must remain unchanged, too. This motivates the equality of both sides of (15).

Intuitively, too, does it make sense that the MM-locus is steeper (and not flatter) than the KK-locus. We have seen that any joint inflow of labor and capital along the KK-locus keeps the wage *as well as* the capital rental constant. But along with a higher number of immigrants, land rents will rise, too (see (12)). If the typical immigrant household is to stay in Island, he must receive compensation not only for the reduction

¹⁶ For example, the wage is equal to the value marginal product of an additional unit of labor used in the electronics sector. This value marginal product is homogeneous of degree zero with respect to capital and labor employed in this sector.

in the wage due to the higher labor force. He must also be compensated for these rising land rents.¹⁷ - In Figure 1, overall equilibrium is where the two loci intersect. The arrows give the dynamics of capital and labor that will set in in disequilibrium. From these arrows, we can tell that the equilibrium in A is *stable*. It is this stability which makes comparative statics, to which we turn next, meaningful.

4. Comparative Statics

We assume that the Island government increases the level of the public input \mathbf{g} . After all, no agent in the private sector has any incentive to do so. As can be seen from equations (7) to (10), a change in \mathbf{g} impacts on both equilibrium loci. In Figure 2, the effect of an increase in the public input on the KK-locus is to shift it unambiguously *upwards* since $r_{Kg} > 0$. However, the effect of $d\mathbf{g} > 0$ on the MM-locus is ambivalent. The change in K needed to restore equilibrium along the MM-locus for *given* M is given by

$$(16) \quad \frac{dK}{d\mathbf{g}} = -\frac{1}{r_{LK}} \left[r_{Lg} - \frac{q}{L} + \frac{1}{\mathbf{d}} \left(e_q^m + \frac{\mathbf{g}}{L} \right) \right]$$

Here, more of the public input makes both industries more productive which in turn ask for more labor, thereby bidding up the wage rate: $r_{Lg} > 0$. As opposed to this single positive effect, a higher \mathbf{g} directly leads to higher taxes. According to (12), a higher \mathbf{g} also directly raises the land rent, thereby increasing the total costs of public input provision (and, therefore, taxes) once more. Worse even, the rising land rent drives up immigrant households' expenditure for land, leaving them less income to spend on other goods.

We have to distinguish between two interesting cases, then. In the first case, as represented in Figure 2, the expression in square brackets in (16) is *positive* so that

¹⁷ Here we have neglected the positive role of a higher population for the tax rate. But, given our Stability Assumption, this positive impact is always dominated by the negative impact of higher land rents. (See equation (13) and subsequent discussion).

higher government activity must be accompanied by a *lower* level of capital. The MM-locus shifts downwards. In the second case, sketched in Figure 3, the expression in square brackets in (16) is *negative* so that more government must be complemented by more capital. Accordingly, the MM-locus shifts upwards. We will return to this alternative scenario in the following section. Here we focus on the first case.

In Figure 2, the new stable equilibrium is at C , at the new intersection of the two loci. In C , labor as well as capital have increased. It is standard to split the adjustment process from the old to the new equilibrium into two parts. Assuming that labor is only mobile in the long run while capital reacts immediately to international differences in rentals, we can identify a “sequence” of adjustments. In the short run, only capital flows from the Rest of the World into Island while no immigration occurs. This leaves the economy in the immigrant disequilibrium at B , creating an incentive for Mainland households to move to Island. In the long run expansion from B to C , labor and capital jointly move into Island, eventually settling at C .¹⁸ Interestingly here, capital and labor *reinforce* each other.

The adjustment from A via B to C has interesting implications for Island’s industrial structure. In the short run, the inflow of electronics capital strengthens the FDI-industry’s productivity. That in turn enables her to pull labor away from food. Hence, in the short run, there is a *boom* in the FDI-industry to the *detriment* of the food industry. This picture changes somewhat over the course of the economy’s movement from B to C . Although capital still keeps flowing in, attracting labor away from food, now labor flows in, too, benefiting both sectors. This is a joint movement along the $K'K'$ -locus, so that another unit of labor is accompanied by $-r_{KL}/r_{KK}$ units of capital (see (14)). From our earlier discussion (or, alternatively, from the Appendix) we know that this joint inflow leaves not only the rental, but also the wage unaffected. This constant wage certainly equals the value marginal product of labor in the food sector after the public investment has taken place, i.e. $(g + dg)f_L^F(C, L - L_E)$. The latter expression then must stay the same, too. But for a fixed capital stock in the food sector

¹⁸ In this paper, a long run movement always refers to the movement from the short run equilibrium to the final equilibrium (and not to the movement from the initial to the final equilibrium).

C this implies that the labor employed in the food sector $L - L_E$ stays the same, too. So in the short run the food industry *declines* while it “only” *stagnates* in the long run.¹⁹

We should associate B with the open small economy and C with the *very* open small economy. In the short run, when moving from A to B , wages rise because of both the increase in g and the induced inflow of capital. Also, land rents increase. Since the economy’s GNP is equal to wage income plus land income, GNP clearly rises. In the long run, when moving from B to C , GNP rises even further. While the wage rate now stays constant along the $K'K'$ -locus, employment in the economy expands. Also, the land rent continues to increase.

It appears that labor’s option to migrate into the very open small economy increases the inflow of capital *beyond* the expansion that would have taken place in the case of the open small economy. So allowing households an additional spatial flexibility increases the g – shock’s expansionary impact on the economy’s GNP. While the extra rise of the economy’s GNP thus seems an attractive feature of the very open small economy, it also raises the question of whether an outflow of capital might be reinforced by a simultaneous outflow of labor. This last point suggests that stronger GNP-fluctuations could occur in the very open small economy as opposed to the merely open small economy.

In the context of the model, different sources of exogenous shocks to Island’s economy come to mind. Here we focus on the case where, because of Island’s negligible political clout in international organizations, Island’s government might be forced to increase its tax rate on electronics capital. In the case of Ireland, for instance, Krugman (1997, p. 53) fears this type of adverse shock to come from the efforts of the European Union to harmonize taxes on mobile capital across all member countries.

¹⁹ Also note that the relative autarky price of electronics falls. To be sure, this marginal change is unlikely to affect the comparative advantage.

If we reinterpret r as the rate of return prevailing in the rest of the world *plus* any taxes on capital in Island, a rise in r could reflect the scenario where Island unilaterally raises its tax on mobile capital. From equations (7) to (10), we can see that such a policy move only affects the KK-locus. In Figure 4, the KK-locus shifts *downwards*, giving rise to a new long run equilibrium in C . The short run equilibrium is in B . As in the preceding section's scenario the short run effect becomes even more pronounced in the long run, as a result of the combined outflow of labor and capital. So again we have the result that in the long run flows of mobile factors *reinforce* each other. Only, here this mutual reinforcement happens to depress Island's economy. More generally, in a response to a rise in r the *very* open small economy's GNP shrinks more than the open small economy's GNP.²⁰

5. Welfare

In the previous section, we have focused on factor flows into the Island economy that may result from public investment. Ultimately, though, we must be interested in changes in Island households' welfare rather than in the mere size of the Island economy. These welfare changes crucially hinge on the *very*-open-small-economy-assumption, i.e. on perfect labor mobility between Island and Mainland. First, by the assumption embodied in (5), incumbent immigrant households do not experience any change in utility across equilibria. Second, reverting back to our discussion of (11), indigenous household utility unambiguously increases as land rents rise. In figure 2, the new equilibrium C is clearly *Pareto-superior* to the old equilibrium A . - While this Pareto-superiority is reassuring, the deepened discrepancy between immigrant utility and indigenous household utility is not.

Where do the income increases for immigrant households from higher productivity and higher electronics capital go? Differentiating no-migration-condition (8) totally gives

²⁰ Curiously, the scenario of an FDI-industry that leaves the host economy does not seem to be a recurrent theme in the economics literature, not even in countries that are largely dependent on it. See, as an exception, the concern expressed by Ruane and Görg (p. 19) in the case of Ireland.

$$(17) \quad (e_q^m + \frac{g}{L})dq = (r_{LK}dK + r_{LL}dM + r_{Lg}dg) + \frac{gq}{L^2}dM - \frac{q}{L}dg$$

The right-hand side of (17) collects the different sources of net income gain to incumbent immigrants. The terms in brackets give the change in the gross wage dr_L . To this, add the agglomeration benefit from sharing the cost of the pure public input with more households. From this, take away the increase in individual taxes due to higher infrastructure costs. In the new equilibrium C , immigration from Mainland to Island has driven the land rents up to a level where the income gains from higher net wages and economies of agglomeration is *completely* offset by higher rents.

Note that $(e_q^m + g/L)$ corresponds to an immigrant household's effective demand for land. This expression includes land for personal use e_q^m as well as land „indirectly“ consumed, i.e. an immigrant's tax share of government demand for land. Multiplying (17) with M and replacing $M(e_q^m - g/L)$ by making use of the land market equilibrium (9) give

$$(18) \quad I(1 - e_q^i - \frac{g}{L})dq = M(r_{LK}dK + r_{LL}dM + r_{Lg}dg) + \frac{M}{L}(\frac{gq}{L}dM - qdg)$$

This then is the essence of introducing costless migration: In the new equilibrium C all potential income gains to incumbent immigrant households have *capitalized* into higher rents. Note that the left hand side of (18) represents effective net land supply of indigenous households, multiplied with the change in land rent. Thus, the increase in indigenous households' aggregate rent income derived from immigrants *exactly* equals the increase in aggregate gains that would have accrued to immigrants had capitalization not taken place. This clearly calls to mind related results in urban economics where, under the „open city“ assumption, migration either within or between cities leads to capitalization.²¹

²¹ For example, see Starrett (1981) and Hartwick (1993). Note that in typical urban economics models the land owner is often not explicitly taken into account. Either the “landlord is absent”, or all income from land is equally distributed among households. Note, too, that unlike “true” urban economics models, this model does not clarify the internal spatial structure of the city.

We have identified the extent of *redistribution* through the land market. In order to take a closer look at the indigenous households, as the beneficiaries of this redistribution, we differentiate (7) totally:

$$(19) \quad du^i = \frac{1}{e_u^i} \left[dr_L + \frac{gq}{L^2} dM - \frac{q}{L} dg + (1 - e_q^i - \frac{g}{L}) dq \right]$$

All terms in square brackets are familiar by now: Income gains for indigenous households include gains from better infrastructure, more capital, and agglomeration economies (minus higher taxes); on top of that they *also* capture the benefits to immigrant households from the same sources.

Using individual marginal utilities of income as weights, we can calculate the welfare change for those households that were present in Island before the public investment shock. This change in aggregate welfare dW is equal to $dW = Ie_u^i du^i + Me_u^m du^m$, then. Exploiting $du^m = 0$, (18), and (19), this simplifies into

$$(20) \quad dW = L(r_{LK} dK + r_{LL} dM + r_{Lg} dg) + \frac{qg}{L} dM - qdg$$

(20) gives the marginal change in aggregate welfare to Island households. The first two terms reflect the marginal benefits of dg , while the last term has the marginal cost of dg . Island society's marginal benefits come from higher wages and agglomeration economies, while marginal costs reflect land lost to infrastructure. Of course, because changes in the land rent are purely redistributive, they do not enter the aggregate welfare change. Note, too, that changes in aggregate capital income cannot feature in (20) because they only affect households residing elsewhere. As non-residents these households are irrelevant to Island welfare.²²

²² We also neglect the gains accruing to newly arriving immigrants.

In comparing (20) with (18), we see that the aggregate welfare change can also be expressed in terms of the change in aggregate rent payments of immigrant households:

$$(21) \quad dW = I(1 - e_q^i - \frac{\mathbf{g}}{L}) \frac{L}{M} dq$$

We could call (21) a corrected „*hedonic benefit measure*“. The insight here is that (marginal) aggregate welfare changes dW can actually be calculated from (marginal) aggregate effective rent income changes, i.e. $I(1 - e_q^i - \mathbf{g}/L)dq$. In an urban model lacking a separate class of landowners, the complete benefit to Islanders induced through public investment would simply be Idq (see, as an example, Kanemoto (1988)). In this model, in contrast, Idq has to be corrected twice. First, not all available land is actually supplied to renters, leaving an effective land supply of only $I(1 - e_q^i - \mathbf{g}/L)$. Second, income increases for land owning indigenous households naturally do not capitalize into higher rents. The expression for the welfare change in (21) takes these two corrections into account.

Equation (21) can provide interesting information for the Island government. The welfare change dW is positive if and only if $dq > 0$. But dq is observable. So the change in rent may serve as an *indicator* to government indicating the sign of the welfare effect of public investment into the public input. Beyond the information on the sign of the welfare change, government might also want to calculate the *extent* of the welfare change. In (21), the Island population’s composition (M and I) and overall size (L) are observable as are government land use \mathbf{g} and indigenous households’ lot size e_q^i . - The hedonic benefit indicator is useful: not every increase in \mathbf{g} is welfare enhancing. As an illustration of a counterproductive public investment we briefly look at a scenario left unexplored in the previous section. If the expression in square brackets in (16) is negative, the MM locus, in reaction to $d\mathbf{g} > 0$, shifts upwards, not downwards. This may lead to falling land rents (and so it is drawn in Figure 3), and, hence, to falling Island welfare.

6. A Case Study: Ireland 1970-1999

In its assumptions, the model captures a number of features specific to Ireland. We first turn to the assumptions' Irish equivalents as to where migrants and capital come from as well as to who owns the economy's industries. Next, we contrast the model's results with the Irish experience. In this case study, "Island" should really be read as the Dublin area, not as Ireland as a whole. First, this is because we have modeled an invariable supply of land, an assumption that is more adequate for an urban area than for a very sparsely populated country.²³ Second, the bulk of FDI actually flows into the Dublin region. And third, we would like to include migrants from Ireland's peripheral regions to Dublin into our concept of an "immigrant", too.

"Mainland", on the other hand, not only contains the Irish periphery. Following Fitz Gerald (1999), over the course of the 1990's there has also been net immigration into Ireland. These immigrants are largely emigrants that return from the UK, and from European countries. Hence, UK and Europe should be included in Mainland as well. To give a flavor of this remigration's extent, Fitz Gerald (p. 6) reports that "... by 1996 nearly 20% of the 30-34 age group were returned emigrants". It is in exhibiting such an extremely mobile work force, that Ireland is often considered to be more a "Region of Europe" than a "Country in Europe" (see Krugman 1997, p. 39).

The "Rest of the World", in the model, encompasses the world's remaining households who, as the "investors", own all of Island's electronics capital as well as food capital and who thus receive all income from these specific factors. According to Barry (1999, p. 51), in 1995 roughly *two thirds* of the total, foreign owned, gross manufacturing output was produced by US subsidiaries. In turn, total gross manufacturing output in Ireland's foreign-owned companies was again roughly *two thirds* of total (foreign owned and Irish owned) gross manufacturing output in Ireland. For modeling purposes, the impressive weight of the US subsidiaries in the Irish industry should allow us to assume a *total* US ownership of at least the manufacturing industry.

²³ The Dublin area seems to suit the assumption of an inelastic land supply remarkably well - being limited in its expansion by the coastline in the East, the Wicklow mountains in the South, the airport

The “Rest of the World” is equivalent to the US, therefore. The model’s GDP/GNP gap shows up in the income flow leaving Ireland. This difference between GDP and GNP has reached approximately 9.5 billion pounds in 1998 (Central Bank of Ireland, 1999, p. 25). Naturally, the connection between this factor income outflow and the current account is not as straightforward as in the model. The trade surplus in 1998, with 18.8 billion pounds, is roughly twice as large as the factor income outflow. Interestingly, this huge surplus is *not* with the United States as might be expected from the ownership of the FDI-industry but rather with the European countries (excluding UK). This why Ireland at times has been called an “export platform”.

The distinction between FDI-industry and indigenous industry in the Irish policy discussion carries over to the model, though in an admittedly very crude manner. On the one hand, the FDI-industry strongly resembles the foreign owned plants that cluster predominantly in electronics, metal, engineering and chemicals. On the other hand, the model’s food industry represents the remaining manufacturing industries in Ireland that are often subsumed as the „indigenous sector“.

We now turn to the model *results*’ equivalents in Ireland. The direct impact of public investment is to increase the return to capital. Also, immigrant household utility rises along with indigenous household utility. The indirect impact of public investment is to attract electronics capital and labor which contribute to increasing production of electronics and food. The model’s “agglomeration” of factors of production in the Dublin area and the ensuing high growth rates of Irish GDP, then, give the “Celtic Tiger”. Also, the Celtic Tiger is characterized by rising net income. This is because otherwise immigrant households would not be able to afford the higher rents (C in Figure 2) without being worse off than in Mainland, something we have excluded in the no-labor-migration-condition which must hold in equilibrium.

Parallel to real growth, the indigenous industry has shrunk up until the mid 1990’s while it has slowly expanded since. Such a “U-curve” is suggested by the model’s results, too, where in the short run (i.e. for a given labor supply) the FDI sector’s

in the North, and environmental concerns in the West. Nevertheless, the urban sprawl appears to

expansion forces the traditional sector to release resources. This is the familiar “resource movement effect” from the literature on resource booms (see, e.g. Corden/Neary, 1982). But in the long run, the traditional sector’s decline comes to a halt.

Finally, we comment on the land rent increase in Ireland’s economy. This is the *urban economics* side of the model. In Figure 2, the immigration of households and the increased government demand for land to build industrial estates on clearly drive up the land rent. - Although the land supply in the Dublin area is in fact not fixed, housing prices have soared over the last years. O’Connell and Quinn (1999, p. 69) present data for the Dublin area, according to which the price of second hand residential housing in 1998 alone rose by 35%.²⁴ Here the model offers the following interpretation: The economic boom generates income gains for all households. But via immigration the income gains of non land owning households are quickly capitalized into rents. Rising housing prices, then, rather reflect the strength of the Celtic Tiger than a “bubble” in the housing market.

In this context it is tempting to try a Public Choice perspective. According to Eurostat’s (1996) data on Ireland, the share of “rented dwellings” in the “total stock of dwellings” in 1993 amounted to a mere 18%. This figure is certainly only *vaguely* related to the gains from land ownership that are prominent in the model. But we might still expect the surge in housing prices to meet a more widespread acceptance in Irish society than with the much lower level of homeownership so typical of many other countries.

continue nevertheless (with the exception of Easterly directions). See Williams/Sheels (2000).

²⁴ For a much more detailed discussion, see Roche (1999).

7. Conclusion

As central *results* of public investment into the very open small economy's general infrastructure we find:

- (1) **Agglomeration.** Public investment causes the expected inflow of mobile capital. But labor flows in, too. These two inflows reinforce each other.
- (2) **Sectoral Change.** Factor inflows affect the balance between the two domestic industries. The industry using mobile capital expands. The other industry suffers.
- (3) **Efficiency.** In the new equilibrium, indigenous households are better off, while immigrant household utility stays the same. The new equilibrium is *Pareto-superior*.
- (4) **Redistribution.** Income gains to immigrant households are completely capitalized into higher rents, thus being redistributed to land owners. Inequality rises.
- (5) **Policy.** In the model, we derive a "hedonic benefit measure" that gives the welfare gain from public investment. This measure uses observable data on rents, land owners and renters, government land use, and effective land supply.

And a prediction on the economy's reaction to a negative shock is the following:

- (6) **Vulnerability.** For a rise in the domestic tax on mobile capital, mobile capital and immigrant labor leave. These outflows reinforce each other. The *very* open small economy appears more vulnerable than the open small economy.

In many respects do predictions (1) through (4) fit the recent Irish boom well. Do these results generalize? For example, we could test the model's predictions by looking at other very open small economies that are also attracting strong inflows of FDI and labor such as Singapore, Hong Kong, and Luxemburg. But maybe there is an even broader range of potential applications. Maybe FDI inflows are much more localized than the available data on the national and regional level suggest. Warsaw and Budapest, for example, appear to be the main recipients of FDI in Poland and Hungary. In these cases, the "open city"-model could prove a helpful framework when analyzing two issues central to FDI: What are its overall benefits to the host country? And how are these benefits distributed?

Appendix

We want to show that (15) holds with equality.

$$(15) \quad -\frac{r_{LL}}{r_{LK}} \geq -\frac{r_{KL}}{r_{KK}}$$

We do this in four steps. First, equilibrium in the labor market holds if aggregate labor demand equals exogenous labor supply L :

$$(A1) \quad g_{E}^p f_L^E(K, L_E) = g_L^f(C, L - L_E)$$

From this, we can infer that the optimal labor allocation L_E reacts to exogenous changes in L and K , i.e. $L_E = L_E(K, L)$.

Second, we recall that the wage rate r_L and the capital rental r_K are equal to the value marginal products of labor and capital at the revenue maximizing allocation of labor, respectively:

$$(A2) \quad r_K(K, L, \mathbf{g}) = p_E g_K^E(K, L_E, \mathbf{g})$$

$$(A3) \quad r_L(K, L, \mathbf{g}) = p_E g_L^E(K, L_E, \mathbf{g})$$

Using (A2) and (A3), we can calculate the reactions of wage and rental to changes in L and K , i.e. r_{KK}, r_{KL}, r_{LK} and r_{LL} .²⁵ In doing this, however, we have to account for the change in the optimal labor allocation $L_E = L_E(K, L)$, too. Dropping the arguments for more transparent exposition, we thus have

$$(A4) \quad r_{LL} = p_E g_{LL}^E \frac{\partial L_E}{\partial L}$$

$$(A5) \quad r_{LK} = p_E \mathbf{g} \left(f_{LK}^E + f_{LL}^E \frac{\partial L_E}{\partial K} \right)$$

$$(A6) \quad r_{KK} = p_E \mathbf{g} \left(f_{KK}^E + f_{KL}^E \frac{\partial L_E}{\partial K} \right)$$

$$(A7) \quad r_{KL} = p_E \mathbf{g}_{KL}^E \frac{\partial L_E}{\partial L}$$

Third, inserting these expressions into the weak inequality (15) eventually gives

$$(A8) \quad \frac{f_{KK}^E}{f_{KL}^E} \leq \frac{f_{LK}^E}{f_{LL}^E}$$

Fourth, since the partial derivatives of the electronics production function f_K^E and f_L^E are each homogeneous of degree zero in K and L_E , we can apply Euler's theorem and conclude that $f_{KK}^E / f_{KL}^E = -L_E / K$ as well as $f_{LK}^E / f_{LL}^E = -L_E / K$. But this actually implies that (15) holds with equality!

Crucially here, we exploit the property of the specific factors model that each production function only depends on two of the three available inputs. The interpretation of the quotients on both sides of equation (A8) is straightforward. These are the “marginal rates of substitution” that trade off electronics capital against labor in order to keep (i) the wage rate and (ii) the capital rental at a fixed level.

²⁵ Actually, since the revenue function in the Dixit/Norman-framework is twice differentiable, we have $r_{KL} = r_{LK}$.

Figures

Figure 1

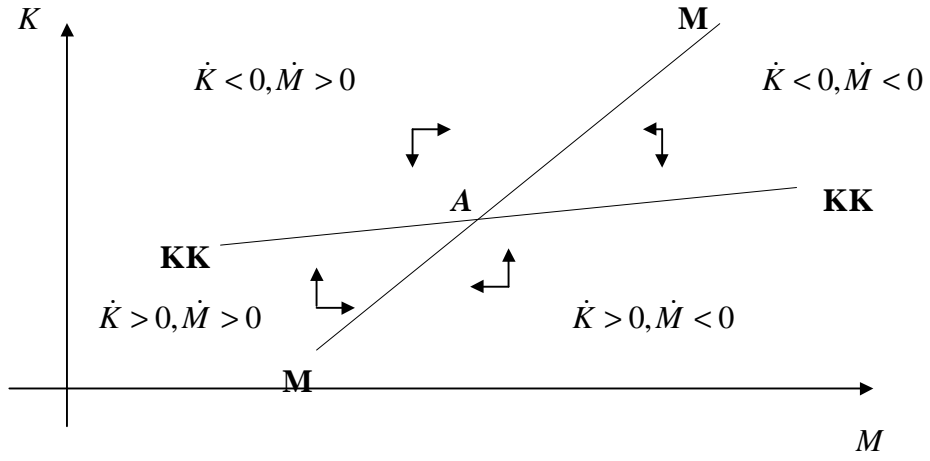


Figure 2:

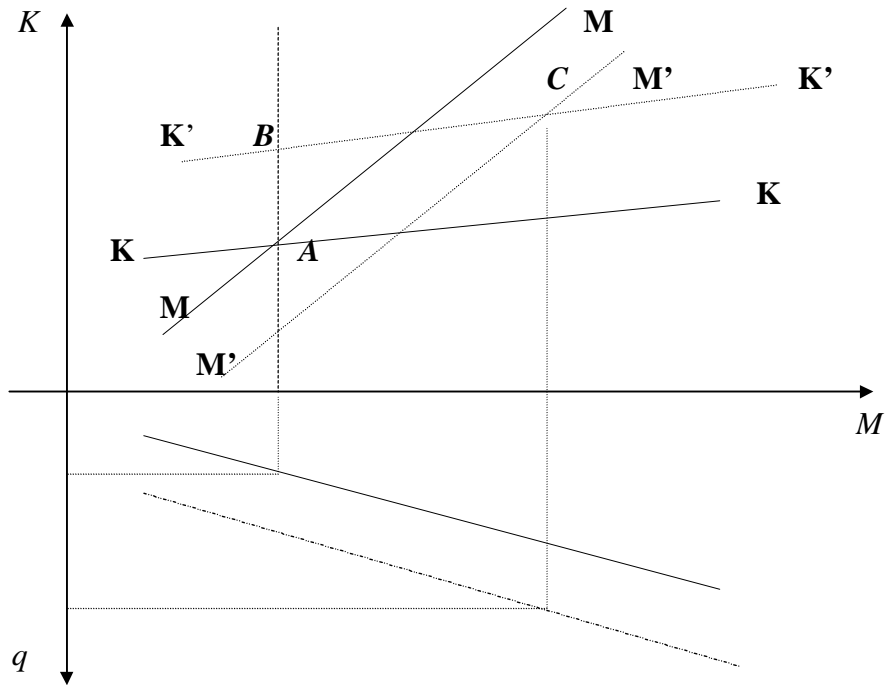


Figure 3:

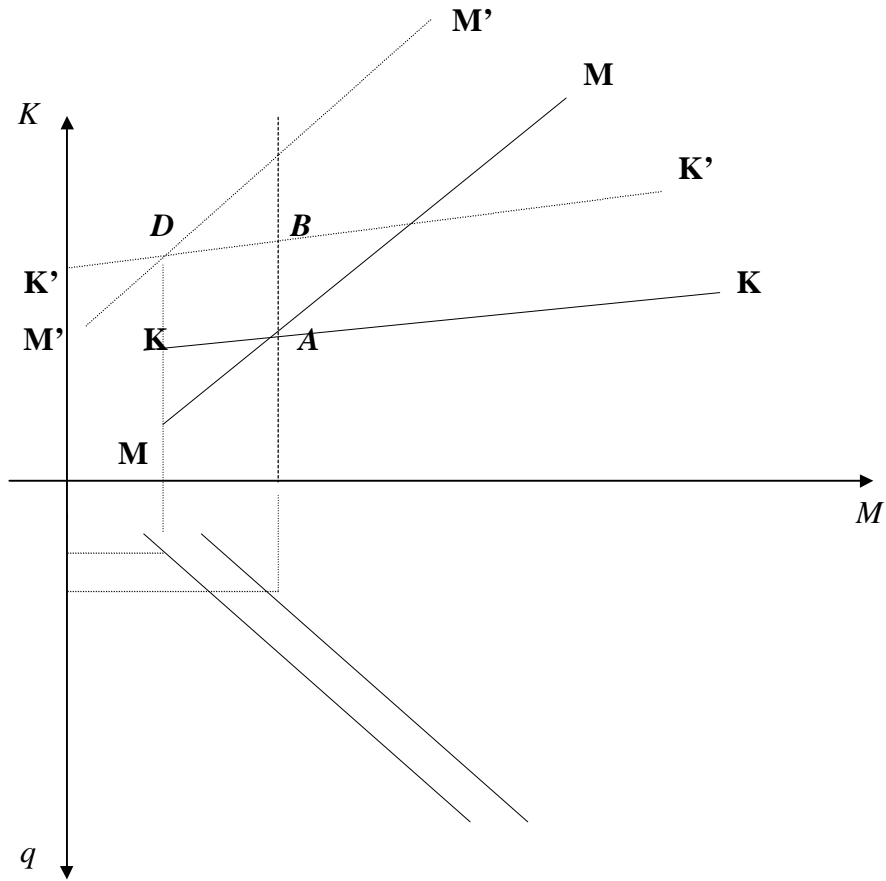
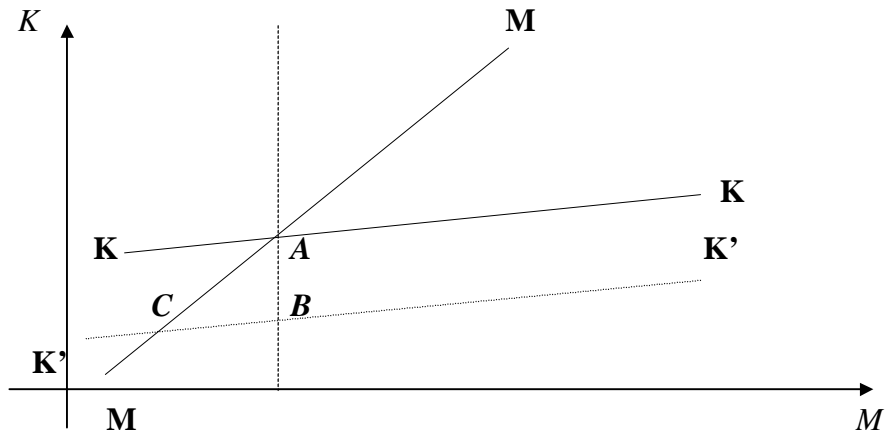


Figure 4: $dr > 0$



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