Institut für Höhere Studien (IHS), Wien
Institute for Advanced Studies, Vienna

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Abstract

This paper explores some links between trade, human capital investment and innovation-based growth in the context of Eastern European economies in transition. Specifically, we calibrate a two region model with trade in differentiated high-tech products and a homogeneous traditional commodity. Human capital, or the quality of the skilled labour force, as well as physical capital are accumulated. Human capital remains finite in the long-run but depends endegenously on education and is an important determinant of the innovation rate. Transition is modelled as one of the two regions starting out with initial conditions that are grossly displaced from a reference path of balanced growth. The paper then evaluates and compares the effects of a number of policy instruments, such as trade liberalization and subsidies for schooling and industrial research, for the process of transition as well as long-run growth and welfare.

Zusammenfassung

Selbst wenn die osteuropäischen Länder die Transformation zu Marktwirtschaften westlicher Prägung erfolgreich bewerkstelligen, und die damit einhergehenden Probleme der makroökonomischen Stabilisierung rasch lösen sollten, wird ihnen danach ein mitunter langer Prozeß der strukturellen Anpassung bevorstehen. Aus theoretischer Sicht stellt sich dieser Prozeß als Übergang von den aus der kommunistischen Vergangenheit geerbten, ungleichgewichtigen Anfangsbedingungen zu einem gleichgewichtigen Wachstumspfad dar. Die Anfangsbedingungen sind unter anderem durch eine zumindest im Vergleich mit Westeuropa geringe Ausstattung mit Sach- und Humankapital, wie auch durch einen geringen Grad an Produktdifferenzierung gekennzeichnet. Eine Schließung dieser Lücken erfordert Investitionen (in Sachkapital, Bildung, sowie F&E), und damit sowohl Ressourcenaufwand als auch Zeit. Die Arbeit versucht, diesen Aufholprozeß mithilfe der modernen Wachstumstheorie näher zu untersuchen. Es wird zunächst ein zwei-Regionen-Modell des endogenen Wachstums entwickelt, in dem nicht nur Sach- und Humankapitalinvestitionen, sondern auch Innovationen (im Sinne einer horizontalen Produktdifferenzierung) endogen erklärt werden. Die beiden Regionen sind sowohl durch internationalen Güterhandel (inter- und intraindustriell), als auch durch perfekte Kapitalmobilität eng miteinander verbunden. Dann wird zunächst auf analytischem Wege das langfristige Wachstumsgleichgewicht dieser zwei-Regionen-Welt und insbesondere dessen wirtschaftspolitische Beeinflußbarkeit charakterisiert. Danach wird das Modell mithilfe einer Kalibrierung numerisch implementiert, um den erwähnten Aufholprozeß numerisch untersuchen zu können. Das kalibrierte Modell soll eine hypothetische, paneuropäische Ökonomie abbilden, in der Mittel- und Osteuropa keine kommunistische Vergangenheit, sondern eine mit den westeuropäischen Ländern vergleichbare Geschichte marktwirtschaftlicher Entwicklung und Integration hinter sich hat, und in der beide Regionen sich auf einem gleichgewichtigen Wachstumspfad befinden. Dieser dient dann als Vergleichsbasis für den durch die erwähnten Rückstände initiierten Aufholprozeß.

Es zeigt sich, daß der Aufholprozeß bei plausiblen Parameterwerten sehr lange dauert. Die sektoralen Sachkapitalbestände erreichen erst nach mehr als vier Jahrzehnten ihre langfristigen Gleichgewichtswerte. Es dauert nicht nur lange, sondern der Aufholprozeß bleibt unvollständig; die langfristigen Gleichgewichtswerte liegen unter den Referenzwerten (d.h. jener Werte, die ohne kommunistische Vergangenheit des Ostens zustandegekommen wären). Die langfristig bestehen bleibende Lücke beträgt bei Sachkapital immerhin 5 Prozent, bei dem durch F&E akkumulierten Wissensbestand sogar 15 Prozent. In weiterer Folge versucht die Arbeit die Rolle der Wirtschaftspolitik für diesen Aufholprozeß zu beleuchten. Dies geschieht, indem dem laissez faire Anpassungsprozeß durch verschiedene Politikmaßnahmen beeinflußte Anpassungsprozesse gegenübergestellt werden. Untersucht werden neben protektionistischen Maßnahmen (des Westens wie auch des Ostens) eine F&E Subvention und eine Bildungssubvention im Osten. Hierbei erweist sich, daß der Osten durch eine im Westen betriebene Protektion "sensitiver" Produkte Schaden erleiden würde, während er durch die (vielleicht als Retorsion verstandene) Errichtung von Importbarrieren für high-tech Importe aus dem Westen bis zu einem gewissen Grade profitieren würde. Die Gewährung einer F&E Subvention führt ebenso wie die Bildungssubvention zu einer nachhaltigen Erhöhung der Wachstumsrate (auch im Westen). Wenn jedoch - wie im vorliegenden Modell - unterstellt wird, daß die Bildungsinvestition keiner Externalität unterliegt, dann ist im Falle der Bildungssubvention die Erhöhung der Wachstumsrate mit einem Wohlfahrtsverlust verbunden.

Keywords

research and development, human capital accumulation, trade and growth, computable general equilibrium modeling

JEL-Classifications

F12, F43, O31, D58

Comments

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1 Introduction

The demise of communism in Central and East European countries (CEECs) has set the European continent on a path of rapid change, challenging economic policy makers not only in post-communist countries themselves, but also in Western Europe. Having rid themselves of communist governments in 1989-90, people in the CEECs soon faced dubious rewards. Their economies experienced an unprecedented crisis, with successive double-digit annual reductions in real GDPs and mass-unemployment. Lacking both previous historical experience and an accepted theory of systemic transformation, observers had a hard time interpreting what was going on. Was it an unavoidable prelude to the formation of a capitalist system, something along the lines of Schumpeter's creative destruction? Were these countries actually heading towards a capitalist system of the Western-type, or did they try to go for some idiosyncratic mixture of communist-capitalist societies? In the meantime, economists more or less unanimously agree that the CEECs will eventually emerge as market economies of the Western type, and that they will do so to their own great advantage. However, controversy still dominates as to the detailed policies of transformation. This holds true in particular with respect to privatization and industrial restructuring, while historical experience and theory seemingly offer somewhat more guidance on issues of macroeconomic stabilization.

Given the necessity of immediate action, it is not surprising that much of the discussion has so far been centering on policies pertaining to systemic transformation, as for instance evidenced by Clague and Rausser (eds., 1992), and Blanchard, Froot and Sachs (eds., 1992). However, very soon economists also started to think about what the European economic map might look like in the post-transformation era, instead of focusing on the policy details of how to get there. Thus, very early on there was a great deal of interest in the potential volume and pattern of trade between Western Europe and the CEECs, for the simple reason that any piece of reliable information would help policy makers in the West in trying to anticipate likely adjustment problems. Evidence for this kind of interest can be found in the studies by Wang and Winters (1991), Collins and Rodrik (1991), Hamilton and Winters (1992), and Baldwin (1994). A preferred approach of these studies was to estimate a model that explains trade for Western European countries, and then to apply this model to post-transformation CEECs, on the assumption that this same model will also fit the latter countries once they have completed their tranformation to market economies.[1] The most difficult step with this approach is to obtain reliable information on the relevant post-transformation characteristics for the Eastern countries (such as factor intensities, productivities, trade shares and the like). The studies reveal enormous potentials for increased trade beteen East and West. Using a calibrated partial equilibrim model for the EU featuring scale economies and imperfect competition, Rollo and Smith (1993) explore the role of sensitive products in this picture by assuming a 400 percent increase of CEEC exports to the EU. However, even for such an enormous trade shock they conclude that the threat of increased import competition from the East may have been exaggerated when designing the European Agreements with the CEECs. As opposed to Rollo and Smith who abstain from any explicit modeling effort for the CEECs, Brown et al. (1995) incorporate CEECs in a static computable general equilibrium model of the world economy to estimate trade and welfare effects of bringing some of them into the EU. Again, this approach basically assumes that the Eastern countries have been successfully transformed into market economies, and that they may be modeled on an equal footing with Western countries. Instead of alluding to non-observable post-transformation country characteristics, they use 1992 observations on CEECs when calibrating their model. This avoids speculating about the future course of events, but it raises the question of whether post-transformation CEECs will continue to exhibit structural characteristics of 1992. One of the conclusions from the experiment is that EU-CEEC integration holds sizable welfare stakes for CEECs, but only minor gains for the EU. In an attempt to extend results pertaining to Austria's recent EU membership to the Visegrad countries, Keuschnigg and Kohler (1995b) similarly find large welfare gains that Eastern countries might obtain through EU integration. Somewhat surprisingly, however, Brown et al. (1995) conclude that sectoral and distributional implications for EU-countries are rather small in magnitude.

In this paper we present a thought experiment which is different from, but complements the above mentioned studies. Suppose that, contrary to all present experience, it were possible to install a Western-type economic system in the CEECs within a relatively short period. Although comparable in terms of how their economies work, Eastern countries would then still be faced with initial conditions that are vastly different from those of their Western counterparts, and different from what they would be if they hadn't had a communist past. Having successfully completed systemic transformation, they would, for instance, still find their physical capital stocks old and outdated. Part of the human capital that was specialized in operating within the old system would become obsolete in a modern market economy. Moreover, given a weak past record of innovation, the structure of production would be heavily biased towards standardized goods. These and several other related gaps must be seen as an economic legacy of the communist past, the common element being that they can only be closed through time. Formally speaking, they relate to stock variables where discrete jumps are impossible. This suggests a distinction between *systemic transformation* and *transition.* The former relates to a fundamental change in the way an economy operates, and in the present context it means creation of a Western-type market economy – installing the logic of market incentives. The latter relates to initial conditions, and it means that, even with the logic of market incentives firmly in place, these economies would start from initial conditions that are grossly displaced from a balanced growth path, not unlike the West after World-War-II. Accordingly, they must be expected to reach their new steady-state paths only after a potentially long period of transition. Even if transformation is successfully accomplished, a balanced long-run growth equilibrium of the transformed CEECs will take a substantial amount of time to materialize.

On the basis of this distinction, our thought experiment now runs as follows. Suppose, that we have a suitably calibrated model of how Western-type market economies operate at any point in time, as well as how they evolve through time. Moreover, in line with the basic premise underlying some of the above mentioned studies, suppose that, broadly speaking, the CEECs would be like average West European countries if they had had no communist past, and if they had been participating in post-World-War-II European integration. Resorting to some bold auxiliary assumptions it should then be possible to arrive at a very stylized, but numerically specified model of how the Pan-European economy might now look like if there had been no communist past in the East. We take this as a reference path of balanced growth. Assuming successful *systemic transformation* and, therefore, keeping the structure of the (Western-type) model, we then introduce the economic legacy of Eastern communism by suitably adjusting several stock variables, and subsequently calculate the *transition* path from such unfavourable initial conditions to what might be called the post-transformation *steady-state.*

The empirical claim of such an exercise is, of course, quite limited. For one thing, the distinction between transformation and transition, though helpful in organizing our thinking, is in some sense artificial. In particular, we cannot claim to portray *actual* transition paths of the early phases where historical continuity in the realm of society and polity interacts with the more or less gradual encroachment of the logic of market incentives. Instead, what we propose to do with this kind of thought experiment is to notionally isolate those aspects of transition that arise purely because history donates very unfavourable economic stocks to transition economies. We do so by way of a numerical example relying on as much empirical information as possible. Moreover, by focusing on transition we restrict our attention to long-run growth and allocation, while problems of short-run stabilization (as a result of systemic transformation) are beyond the scope of our analysis.

Quite naturally, the usefulness of this exercise is limited by the structure of the model used and by the level of detail that it incorporates. The model will, almost by necessity, have to be rather stylized. What are the elements that one would nonetheless want to highlight, given that we concentrate on transition? There is probably no clear-cut answer to this, but we argue that international trade and capital flows should figure very prominently in the model structure. Further key elements should be accumulation of capital, both physical and human, as well as R&D and innovation. And finally, the model should provide for some role of economic policy regarding the aforementioned elements.

In developing such a model, we draw on recent literature on innovation-based growth in the context of a global economy, as well as on the literature emphasizing the role of human capital for growth. More specifically, we combine the models of horizontal product differentiation pioneered by Romer (1987,1990) and Grossman and Helpman (1991) with models of endogenous accumulation of human capital, pioneered by Lucas (1988, 1993) and Chamley (1993). However, we assume that unbounded accumulation of human capital is prevented by the simple fact that human capital, unlike financial wealth, cannot easily be passed on from one generation to another. Old agents lose part of their skills in the process of aging and eventually all may be lost by death. One way to incorporate bounded human capital accumulation in an aggregate growth model – short of explicitly modeling and aggregating the life-cycle education decisions of overlapping generations – is to assume diminishing returns to education with respect to the human capital stock. Consequently, we adopt the view that the general knowledge stock, the stored ideas from accumulated past R&D results, may grow without bounds while the human capital stock, or the quality of the high skilled labour force, eventually stops to grow. Nevertheless, the level of the human capital stock is endogenous and importantly determines the innovative capacity in the economy.

In the next section we present the details of such a model for a two-region world economy. Before we turn to a numerical implementation of the model, we derive several analytical results on long-run growth in section 3. Section 4 then discusses the procedure that we have chosen to calibrate our model towards the transition experiment mentioned above. Section 5 first presents the scenarios and then turns to the role that trade policy, R&D policy, and educational policy may play for the transition paths.

2 A Growth Model of the World Economy

We now develop a two-region model of the world economy with educational investments and increasing product variety based on knowledge driven innovation. Growth in the high-tech sector is driven by the innovations of profit motivated entrepreneurs in the research sector who draw on a pool of high-skilled labour. The quality of the high-skilled labour force in each country hinges on past educational investments. Entrepreneurs pursue costly research and development efforts motivated by the prospects of subsequent monopoly profits from production of newly invented products. An expanded product range contributes to productivity gains due to increasing specialization and division of labour. These make investments in physical capital more profitable and, thus, provide incentives for continued capital accumulation. The model, formulated in discrete time, is a combination of Grossman and Helpman (1991) [see also Ruffin (1994)] and Romer (1987, 1990).

Education and Consumption: Consumers worldwide share common preferences over a range of sophisticated high-tech consumer goods as well as a homogeneous traditional good C_Y. Given homogeneous preferences, demand for high-tech goods may be thought of as demand for a composite good $C_{\bar{X}}$ that is available at a price index $P_{\bar{X}}$ and is formed from a range of differentiated varieties c_x^j, as detailed below. Assuming homothetic preferences over the two broad types of consumer goods, $\tilde{u}(C_Y, C_{\bar{X}}) = u[\bar{C}(C_Y, C_{\bar{X}})]$, allows convenient aggregation of all demands into an overall commodity basket $\bar{C}$. Then, overall consumer spending in any given period amounts to $\bar{C}\bar{P} = P_Y C_Y + P_{\bar{X}} C_{\bar{X}}$, where $\bar{P}$ is an exact consumer price index. Agents discount utility from future consumption with a factor ρ that equals one plus the subjective discount rate, and allocate consumption over time by maximizing a time-separable lifetime utility function

$$U_t = \max \sum_{s=t}^{\infty} \rho^{t-s} u[\bar{C}(C_Y, C_{\bar{X}})]. \tag{1}$$

Agents accumulate financial assets A to achieve their preferred lifetime consumption pattern. The return on assets is reflected in the interest factor r which equals one plus the interest rate. Savings out of interest income $(r-1)A_{-1}$ and disposable wage income $w_D = w_L L_L + (u + (1-u)\tau_E) w_H H_{-1} L_H - T$ determine the accumulation of wealth[2]

$$A = rA_{-1} + w_D - \bar{P}\bar{C}, \qquad H = g(e)H_{-1} + \delta_H H_{-1}, \qquad e = (1-u)/H_{-1}. \tag{2}$$

The low-skilled labour force L_L performs standardized manufacturing tasks that do not require much training. It is in fixed supply and earns a wage w_L.[3] By way of contrast, high-skilled labour L_H performs tasks that require specific training and schooling. Endowed with a time budget equal to unity, people belonging to L_H may work for a fraction of time u and earn an effective wage rate $w_H H_{-1}$ that depends on their skill level H_{-1}. They may enhance their skills and thus their future earnings potential by using the fraction $1-u$ of their time for schooling and training. The government may subsidize this activity by paying a fraction τ_E of the forgone wage income, but levies a lump-sum tax T to cover its expenses. Given that skills deteriorate at a rate δ_H, continuous training and schooling is necessary to prevent skills from becoming obsolete. The educational technology is embodied in a function $G(1-u, H_{-1}) = g(e)H_{-1}$ which is linearly homogeneous and increasing in both arguments. The intensive form satisfies $g'(e) > 0$ and $g''(e) < 0$. We impose a convenient normalization: $g(\bar{e}) = \bar{e}$ and $g'(\bar{e}) = 1$, where $\bar{e} = 1-\delta_H$ is the education skill ratio that keeps constant the level of educational attainment in the long run.

Optimal consumption behaviour may be derived using Lagrangean methods. Details on the optimality conditions for consumption, schooling and human capital accumulation are available upon request from a separate appendix. The agents' desire to balance the loss in marginal utility from forgone consumption today against the marginal benefit of future consumption determines the optimal rate of consumption growth. The level of consumption reflects lifetime wealth. With an intertemporal elasticity of substitution equal to γ, the Euler equation for consumption growth is

$$\frac{\bar{C}}{\bar{C}_{-1}} = \left[\frac{r}{\rho}\frac{\bar{P}_{-1}}{\bar{P}}\right]^{\gamma}. \tag{3}$$

A similar consideration determines work effort and schooling. The optimal amount of time spent in school weighs the opportunity cost of forgone current income against the increase in future earnings potential from higher education,

$$V_H g'(e) = w_H H_{-1}(1-\tau_E), \qquad V_H = \sum_{s=t+1}^{\infty} y_s (\delta_H)^{s-t-1} R_{t+1,s}, \tag{4}$$

where $y = [u + (1-u)\tau_E)]w_H + \frac{g(e)-eg'(e)}{g'(e)}(1-\tau_E)w_H H_{-1}$ measures the increase in income from an additional unit of skills and $R_{t+1,s} = \prod_{u=t+1}^{s}(1/r_u)$ is a discount factor. An additional hour spent in school increases skills by an amount $g'(e)$. Increased education, in turn, boosts lifetime earnings. The present value of this marginal income stream equals V_H. The increase in skills directly raises future effective wage income (see the first term in y). Furthermore, by increasing the skill level today, any given time spent in school in the future is more productive. Hence, future educational requirements are achieved with less time in school, and agents afford to earn some income in the factory instead. This indirect effect is captured by the second term in y. Finally, the additional skills acquired today become partly obsolete by aging which erodes their future earnings potential at a rate δ_H. Hence, the value of acquiring an additional unit of skills today is the present value of future wage income per unit of skills, including the savings in future schooling efforts.

In a long-run equilibrium, agents spend a constant fraction of their time in school and in the factory. Due to diminishing returns to education, the skill level remains constant but is otherwise endogenously determined in terms of technology, taste and policy paramenters. Consequently, the education ratio is a constant determined by the stationarity of the law of motion in (2), $\bar{e} = 1 - \delta_H$. Given the normalization of the schooling technology, wage income per unit of skills is $y = [u + (1-u)\tau_E)]w_H$ which grows with a factor $\hat{w}$ and thus attains a present value $V_H = [u + (1-u)\tau_E]w_H/(r/\hat{w} - \delta_H)$. Anticipating the result proved later that consumption expenditure grows at a rate $\hat{w}$, the Euler equation (3) implies $r/\hat{w} = \rho$ when preferences are logarithmic.[4] Consequently, (4) simplifies to $(1-\tau_E)H_{-1} = [u + (1-u)\tau_E]/(\rho - \delta_H)$. Since the long-run education ratio is fixed at $\bar{e} = (1-u)/H_{-1} = 1 - \delta_H$, we derive

$$u = \frac{(1-\tau_E)(\rho - \delta_H) - \tau_E \bar{e}}{\nabla} < 1 \qquad H_{-1} = \frac{1}{\nabla} > 0, \qquad \nabla = (1-\tau_E)(\rho - \delta_H + \bar{e}) > 0. \tag{5}$$

How does the effective supply of skilled labour respond to changes in important structural parameters? Starting from a position of $\tau_E = 0$, one derives

$$\begin{array}{lll} \frac{\partial u}{\partial \rho} = \frac{1-\delta_H}{\nabla^2}, & \frac{\partial H_{-1}}{\partial \rho} = \frac{-1}{\nabla^2}, & \frac{\partial u H_{-1}}{\partial \rho} = -\frac{(\rho-1)}{\nabla^3}, \\ \frac{\partial u}{\partial \tau_E} = -\frac{(1-\delta_H)}{\nabla^2}, & \frac{\partial H_{-1}}{\partial \tau_E} = \frac{1}{\nabla}, & \frac{\partial u H_{-1}}{\partial \tau_E} = \frac{(\rho-1)}{\nabla^2}. \end{array} \tag{6}$$

When agents are less patient, they prefer higher current income and spend more of their time working. Consequently, skills deteriorate and the supply of effective high-skilled labour diminishes. When the government introduces a small subsidy to education, agents find it attractive to spend more time in school rather than in the factory, thus increasing the long-run skill level. Even though time spent working is reduced, the net effect of the subsidy is to raise the effective supply of high-skilled labour services uH_{-1}.

Investment: Part of demand for goods stems from investment in physical capital. Denoting the discount factor by $R_{t+1,s} \equiv \prod_{u=t+1}^{s} (1/r_u)$, maximization of the present value of cash flows determines the optimal rate of capital investments,[5]

$$\max \left\{ \sum_{s=t}^{\infty} [w_K K_{-1} - \bar{P}\Psi(\bar{I}, K_{-1})] R_{t+1,s} \quad s.t. \quad K = \bar{I} + \delta_K K_{-1} \right\}. \tag{7}$$

The composite investment good $\bar{I}$ is formed from the traditional and high-tech goods in exactly the same way as the composite consumption good. Hence, the two price indices are identical. Gross investment in each sector adds to the sectoral capital stock K_{-1} which is otherwise decaying with a factor δ_K.[6] A linearly homogeneous installation technology $\Psi(\bar{I}, K_{-1}) = \psi(i)K_{-1}$ specifies the quantity of the investment composite that needs to be acquired in order to increase the capital stock by $\bar{I}$ units; $i = \bar{I}/K_{-1}$. The intensive form $\psi(\cdot)$ is increasing and convex (for details see the appendix at the end). The installation function reflects adjustment costs and makes it optimal to stretch investment over time rather than adjusting capital stocks instantaneously. Investment in physical capital maximizes the present value of rental earnings $w_K K_{-1}$ in excess of investment outlays. Optimality requires that the return on investment including capital gains must match the return on other assets. In purchasing a unit of the capital good, investors pay an acquisition price $\bar{P}$ and balance marginal costs and benefits of investment. A unit increase of the capital stock generates a stream of future rental income equal to q in present value, but requires an effective investment outlay of $\psi'(i)\bar{P}$. Hence, optimal investment reflects a simple present value criterion

$$q = \psi'(i)\bar{P}, \qquad rq_{-1} = w_K - [\psi(i) - i\psi'(i)]\bar{P} + \delta_K q. \tag{8}$$

Commodity Demand: The overall level of demand for the composite good translates into derived demands for individual commodities. Specifically, differentiated goods are supplied by monopolistic producers that are located either at home or abroad. Suppose that new products become available only in the next period. Then, a total of $\bar{N}_{-1} = N^1_{-1} + N^2_{-1}$ of differentiated brands are available worldwide, with N^1_{-1} produced at home and N^2_{-1} produced abroad. Consumer preferences are characterized by love for variety in the spirit of Dixit and Stiglitz (1977). Then the composition of product demand derives from expenditure minimization which yields an exact price index for the composite good,

$$P^i_X = \min_{c^{ij}_x} \left\{ \int_0^{\bar{N}_{-1}} (\tau^{ij}_B p^j_x) c^{ij}_x dj \quad s.t. \quad \left[\int_0^{\bar{N}_{-1}} (c^{ij}_x)^{\frac{1}{\beta}} dj \right]^{\beta} \geq 1 \right\}, \qquad \sigma = \frac{\beta}{\beta - 1} > 1, \tag{9}$$

where index j indicates one of the home or foreign-produced varieties. Thus, c^{ij}_x is unit consumption demand originating in country i for country j's products. Note that producers charge the same price irrespective of where they sell their product. Demand prices for the same product may, however, differ across countries due to a trade barrier on imports: $\tau^{ij}_B > 1$ for $i \neq j$ and $\tau^{ij}_B = 1$ for $i = j$.[7] Since demand and supply is completely symmetric within the groups of home and foreign-produced varieties, the price index may conveniently be calculated as

$$P_X^i = \left[\int_0^{\bar{N}_{-1}} (\tau_B^{ij} p_x^j)^{\frac{1}{1-\beta}} dj\right]^{1-\beta} = \left[N_{-1}^1 (\tau_B^{i1} p_x^1)^{\frac{1}{1-\beta}} + N_{-1}^2 (\tau_B^{i2} p_x^2)^{\frac{1}{1-\beta}}\right]^{1-\beta}. \quad (10)$$

In the presence of trade barriers, the price index differs across countries. Country 1, for example, spends $P_X^1 D_X^1 = N_{-1}^1 p_x^1 D_x^{11} + N_{-1}^2 (\tau_B^{12} p_x^2) D_x^{12}$ on high-tech varieties. Adding up across different demand categories and countries, country i's expenditure is $\bar{P}^i \bar{D}^i = P_Y D_Y^i + P_X^i D_X^i$ and stems from consumption and investment demand: $\bar{D}^i = \bar{C}^i + \Psi_x^i + \Psi_y^i$.[8] It is important to distinguish carefully between sector x's demand for the composite investment good, Ψ_x^i, and derived demand for the high-tech sector's composite output, D_X^i. This multiplies with unit demand to give the overall quantity that a producer of country j is able to sell on country i's market for high-tech products,

$$D_x^{ij} = [P_X^i / (\tau_B^{ij} p_x^j)]^{\sigma} D_X^i. \quad (11)$$

Monopolistic Production: Each existing variety is produced by a single producer who owns an infinitely lived patent on his brand and, therefore, acts as a monopolist. His market power is limited, however, since varieties are close substitutes in demand. With perfect competition in factor markets, producers take factor prices as given. All producers have access to the same sector specific production technologies which are assumed linearly homogeneous in capital and labour. Per unit of output, producers choose minimizing factor inputs and incur unit costs equal to

$$\begin{aligned} \phi_x(w_H, w_K) &= \min_{h_x, k_x} \{w_H h_x + w_K k_x \quad s.t. \quad F_x(h_x, k_x) \geq 1\}, \\ \phi_y(w_L, w_K) &= \min_{l_y, k_y} \{w_L l_y + w_K k_y \quad s.t. \quad F_y(l_y, k_y) \geq 1\}. \end{aligned} \quad (12)$$

Both sectors use capital. However, low-skilled labour is employed only in the traditional sector while high-skilled labour finds employment either in the high-tech sector or in research and development. The derivatives of the unit cost functions give factor demands per unit of output in country i: $k_x^i, h_x^i, k_y^i, l_y^i$. Individual workshops may rent any amount of capital at a rental rate w_K^i, and may employ high- and low-skilled labour at wages w_H^i and w_L^i where w_H^i is per 'skill-unit'. Thus, capital and labour may be redeployed across workshops without frictions.

In a well-diversified economy, the market for an individual variety is small compared to the size of aggregate demand. Consequently, individual producers have a negligible influence on the price index P_X^i and on the state of aggregate demand in country i.

Hence, they perceive an own price elasticity of demand equal to σ. Given this estimate, they maximize profits $\pi^j = (p_x^j - \phi_x^j)x^j$, where $x^j = D_x^{1j} + D_x^{2j}$. In exploiting market power, producers in country j set a price in excess of marginal costs,

$$p_x^j = \beta \phi_x^j. \tag{13}$$

Since all producers face the same factor prices and since demand is symmetric, implying a uniform price elasticity σ, all producers in country j end up charging identical prices. Markup pricing generates gross profits equal to

$$\pi = (\beta - 1)\phi_x x \tag{14}$$

in each period. The discounted flow of future profits creates monopoly wealth. The equity value of the workshop must generate a rate of return including capital gains that is equal to the economy-wide interest rate, to preclude any unexploited profits from financial arbitrage. Thus, the value of a patent on any variety must satisfy the no-arbitrage condition

$$rv_{-1} = \pi + v. \tag{15}$$

Given a transversality condition, solving this equation forward in time shows that the stock market value of a new patent is equal to the present value of future profits. Since production of a new variety invented in period t commences only with next period, the equity value v_t is defined ex current profits [use the discount factor $R_{t,s} \equiv \prod_{u=t}^{s}(1/r_u)$]:

$$v_t = \sum_{s=t+1}^{\infty} \pi_s R_{t+1,s}. \tag{16}$$

Innovation: The prospects for future profits motivate current efforts on research and development. Innovation generates two basic benefits. It results in previously unknown blueprints for producing new varieties. With well-developed patent protection, a new blueprint gives an exclusive production right resulting in future monopoly profits. In addition, current innovation spills over to the remaining research community and adds to the general knowledge stock which enhances the productivity of other researchers. This additional benefit, however, is non-rival in nature and not appropriable by private entrepreneurs. With immediate diffusion of innovative activity, the current knowledge stock reflects the cumulative experience of past innovations both at home and abroad and, by choice of units, may be equated to the worldwide stock of varieties $\bar{N}_{-1} = N_{-1}^1 + N_{-1}^2$. For simplicity, research is assumed to be an activity of high-skilled labour only. The basic productivity in the research labs is $(\bar{N}_{-1}/a)$ and grows in line with the accumulated past research experience $\bar{N}_{-1}$. Assuming a linear learning by doing technology, the labour input needed to generate $I_N = N - N_{-1}$ innovations, or new products, is given by

$$h_R = aI_N/\bar{N}_{-1}. \tag{17}$$

Research is motivated by profit opportunities from supplying the newly-created product to a worldwide market. The value of a new patent reflects this profit stream. With free entry into R&D activities, agents devote efforts to innovative activities until the forgone wage income in producing existing goods matches the patent value,

$$v \;\substack{=\\<}\; (1-\tau_R)w_H a/\bar{N}_{-1}, \quad \Longleftrightarrow \quad I_N = N - N_{-1} \;\substack{\geq\\=}\; 0. \tag{18}$$

If the value of a new patent fell short of the wage cost of the high-skilled labour input, then research would become unprofitable and all innovative activities would stop. The government may subsidize R&D costs at a rate τ_R.

Excess Demands: We now close the model by adding an economy-wide portfolio condition. Define aggregate monopoly wealth in country i ($i = \{1,2\}$) by $V_m^i = v^i N^i$ and the value of the sectoral capital stocks by $V_x^i = q_x^i K_x^i$ and $V_y^i = q_y^i K_y^i$. Furthermore, agents may hold an internationally-traded bond B^i which is denominated in terms of the traditional good. All assets are assumed to be perfectly substitutable and, therefore, must yield identical returns. The composition of financial wealth in the aggregate is then determined by the supply of assets: $A^i = V_x^i + V_y^i + V_m^i + B^i$. The excess demand system of the world economy is

$$\begin{aligned}
\zeta_L^i &= l_y^i Y^i - L_L^i, \\
\zeta_H^i &= h_x^i x^i N_{-1}^i + h_R^i - u^i H_{-1}^i L_H^i, \\
\zeta_{Kx}^i &= k_x^i x^i N_{-1}^i - K_{x,-1}^i, \\
\zeta_{Ky}^i &= k_y^i Y^i - K_{y,-1}^i, \\
\zeta_x^i &= N_{-1}^i [\textstyle\sum_j (C_x^{ji} + I_x^{ji}) - x^i], \\
\zeta_y &= \textstyle\sum_i (C_y^i + I_y^i - Y^i), \\
\zeta_G^i &= T^i + T_{\tau_B}^i - \tau_E^i (1-u^i) w_H^i H_{-1}^i L_H^i - \tau_R^i w_H^i h_R^i, \\
\zeta_A &= \textstyle\sum_i (A^i - V_m^i - V_x^i - V_y^i) = \sum_j B^j.
\end{aligned} \tag{19}$$

In an integrated equilibrium of the world economy, all excess demands are zero. The first three equations show that factor markets clear separately in each country. Note that physical capital stocks in each country and sector are predetermined in every period, due to adjustment costs of investment.[9] Commodity markets clear worldwide. Since each differentiated product is produced only in one location, there are two equilibrium conditions for home and foreign-produced high-tech goods. Consumer demand originating in country j for a variety produced in country i is C_x^{ji}, and similarly for investment. The government budget constraint ζ_G^i restricts overall expenditures for subsidies to available revenues from lump-sum taxes T^i and from import tariffs, $T^i_{\tau_B} = (\tau_B^{ij} - 1)D_x^{ij} p_x^j N_{-1}^j$, $j \neq i$. Finally, there is a worldwide asset market. With perfectly substitutable assets, agents are indifferent with regard to their portfolio composition. By assumption, all equity issued at home is owned by domestic residents which, in line with stylized facts, excludes cross country equity holdings. Consequently, accumulated savings that exceed domestic equity value are invested in foreign-issued bonds. By definition, a claim of one country is the liability of the other: $B^1 = -B^2$.

The current account balance highlights the role of international capital mobility and its relation to the trade balance. Using budget constraints, pricing and cost equations, and the no-arbitrage conditions, the equation for the household sector's asset accumulation is equivalent to the current account equation $B^i = rB^i_{-1} + TB^i$. The trade balance may be viewed in two alternative ways:

$$\begin{aligned} (a)\quad TB^i &= p_x^i x^i N_{-1}^i + P_Y Y^i + T^i_{\tau_B} - \bar{P}^i \bar{D}^i, \\ (b)\quad TB^i &= P_Y(Y^i - D_Y^i) + N_{-1}^i p_x^i (x^i - D_x^{ii}) - N_{-1}^j p_x^j D_x^{ij}. \end{aligned} \tag{20}$$

Version (a) reflects the difference between GDP and absorption in each country. Alternatively, (b) states the trade balance in terms of the value of exports minus imports. The first term captures one-way trade in the traditional good while the remaining terms reflect two-way trade in differentiated goods which are produced only in one location. The second term gives net exports of those varieties that are produced at home but not abroad, while the third term represents the imported varieties that are not produced at home. Finally, the equilibrium condition for the world capital market, $\sum_i B^i = 0$, amounts to the equality of world income and world spending.

3 Long-Run Growth

In a long run equilibrium of balanced growth, prices and quantities grow at constant rates. The fact that these stationary growth rates differ across various types of variables imposes further restrictions on the production technology. Specifically, the factor prices for capital and labour will grow at different rates. Thus, constant factor shares require a unitary elasticity of substitution in production, hence we specialize the technology to

$$\begin{aligned} \phi_y^i &= \phi_{0,y}^i (w_K^i/\alpha_{ky})^{\alpha_{ky}} (w_L^i/\alpha_{ly})^{\alpha_{ly}}, & l_y^i w_L^i &= \alpha_{ly}\phi_y^i, & k_y^i w_K^i &= \alpha_{ky}\phi_y^i, \\ \phi_x^i &= \phi_{0,x}^i (w_K^i/\alpha_{kx})^{\alpha_{kx}} (w_H^i/\alpha_{hx})^{\alpha_{hx}}, & h_x^i w_H^i &= \alpha_{hx}\phi_x^i, & k_x^i w_K^i &= \alpha_{kx}\phi_x^i. \end{aligned} \tag{21}$$

The same holds true for the allocation of consumption. Due to ongoing product innovation and, consequently, continuous introduction of new specialized varieties, the price index of the composite high-tech good grows at a rate different from that of the traditional good. To support a constant share of expenditure in a balanced growth equilibrium, one needs to specialize preferences to

$$\bar{P}^i = (P_X^i/\alpha_{cx})^{\alpha_{cx}} (P_Y/\alpha_{cy})^{\alpha_{cy}}. \tag{22}$$

To pin down 'nominal' variables and their growth rates, we normalize the price of the traditional good to unity: $P_Y = 1$ and $\hat{P}_Y = 1$ (notice that $\hat{P} = P/P_{-1}$). We start by observing that all spending and income components at home and abroad must grow at a common rate that is identical across countries and equal to the growth rate of wages $\hat{w}$. In particular, wages of high- and low-skilled labour must grow at the same rate since the effective supplies are constant in the long run. To support constant shares in the savings equation (2), financial wealth and consumption budgets must also grow at the same rate. If the net foreign asset position is to remain a constant share of domestic financial wealth, it must accumulate with the same speed. Perfect international capital mobility equates interest rates across countries. Hence, the current account equation in (20) implies that net foreign assets, GDP and absorption grow at the same rate $\hat{w}$ in both countries. In particular, $\hat{N}^i\hat{x}^i\hat{p}_x^i = \hat{w}$. Could the components possibly grow at different rates? Since we require non-specialization in the high-tech sector with constant product shares $s_N^i = N_{-1}^i/\bar{N}_{-1}$, both countries must introduce new products with the same speed $\hat{N}^i = \hat{N}$. Furthermore, the price index P_X^i given in (10) must grow at an identical rate in both countries, implying that the component prices must grow at the same rate $\hat{p}_x$. Then, by virtue of $\hat{N}\hat{x}^i\hat{p}_x = \hat{w}$, factory output must increase at the same rate $\hat{x}$ in both countries. Finally, balanced growth in the world economy is supported only with identical demand shares in (22) and an identical cost share of capital in both countries. Hence, the α-parameters are identical.[10]

The solution in growth rates for isoelastic intertemporal preferences is somewhat complicated and is obtained only in the numerical example below. The case simplifies considerably with logarithmic preferences, $\gamma = 1$, in which case the Euler equation in (3) gives a simple relation between the interest and growth rates,

$$r/\rho = \hat{w} = \hat{N}\hat{p}_x\hat{x}. \tag{23}$$

The resource constraint for high-skilled labour in (19) establishes an additional relationship between the world interest and growth rates. Use (17) and replace the unit demand for high-skilled labour, $h_x^i = \alpha_{hx}\phi_x^i/w_H^i$, to obtain

$$\frac{\alpha_{hx}\phi_x^i x^i N_{-1}^i}{w_H^i} = u^i H_{-1}^i L_H^i + a^i s_N^i(1-\hat{N}). \tag{24}$$

The valuation of monopoly wealth in (14) and (15) yields $(r/\hat{v}-1)v^i = \pi^i = (\beta-1)\phi_x^i x^i$ while the free entry condition (18) may be written as $v^i = (1-\tau_R^i)w_H^i a^i s_N^i/N_{-1}^i$. Combining them, we have $(r/\hat{v}-1)[a^i s_N^i(1-\tau_R^i)]/(\beta-1) = \phi_x^i x^i N_{-1}^i/w_H^i$. Therefore, the resource constraint is

$$\Big(\frac{r}{\hat{v}}-1\Big)\frac{\alpha_{hx}(1-\tau_R^i)}{\beta-1} = 1-\hat{N}+\frac{u^i H_{-1}^i L_H^i}{a^i s_N^i}. \tag{25}$$

The valuation equation of monopoly wealth implies $\hat{v} = \hat{p}_x\hat{x}$. Therefore, by using $\hat{w} = \hat{v}\hat{N}$, one may conveniently rewrite the Euler equation as $\rho\hat{N} = r/\hat{v}$. Upon collecting terms, the resource constraints of the two countries become

$$\Big[1+\rho\frac{\alpha_{hx}(1-\tau_R^i)}{\beta-1}\Big]\hat{N} = \frac{\alpha_{hx}(1-\tau_R^i)}{\beta-1}+1+\frac{u^i H_{-1}^i L_H^i}{a^i s_N^i}, \qquad i=\{1,2\}. \tag{26}$$

The two constraints determine the two unknowns, the worldwide rate of product innovation $\hat{N}$ and country 1's share in the product line, s_N^1. Note that the effective supply of skilled labour $u^i H_{-1}^i L_H^i$ in each country is determined by preference and technology parameters , as well as by policy [see (5) and (6)]. Figure 1 gives a graphic illustration, plotting the innovation rate on the vertical axis and the country share on the horizontal axis. The two curves represent the resource constraint of the two countries for high-skilled labour. The floor levels give the innovation rates that each country would have achieved as a closed economy, or in the absence of knowledge spill-overs. The intersection of the two constraints determines the world innovation rate and pins down the country share in the worldwide number of products. Obviously, the innovation rate of the integrated world economy must exceed the autarkic rate of each country.

Education and R&D Subsidies to Promote Growth: The total differential of (26) reveals how the two curves shift in response to government intervention,

$$\begin{aligned}\hat{N}\Big[1+\rho\tfrac{\alpha_{hx}(1-\tau_R^i)}{\beta-1}\Big]\Big(\tfrac{d\hat{N}}{\hat{N}}\Big) \quad = \quad & -\tfrac{u^i H_{-1}^i L_H^i}{a^i s_N^i}\Big(\tfrac{ds_N^i}{s_N^i}\Big) \\ & + (\rho\hat{N}-1)\tfrac{\alpha_{hx}}{\beta-1}d\tau_R^i + \Big(\tfrac{\partial u^i H_{-1}^i}{\partial \tau_E^i}\Big)\tfrac{L_H^i}{a^i s_N^i}d\tau_E^i, \quad i=\{1,2\}.\end{aligned} \tag{27}$$

The first coefficient on the r.h.s. gives the slope of the resource constraints RR^i at the initial equilibrium position. The last two coefficients determine the upward shift

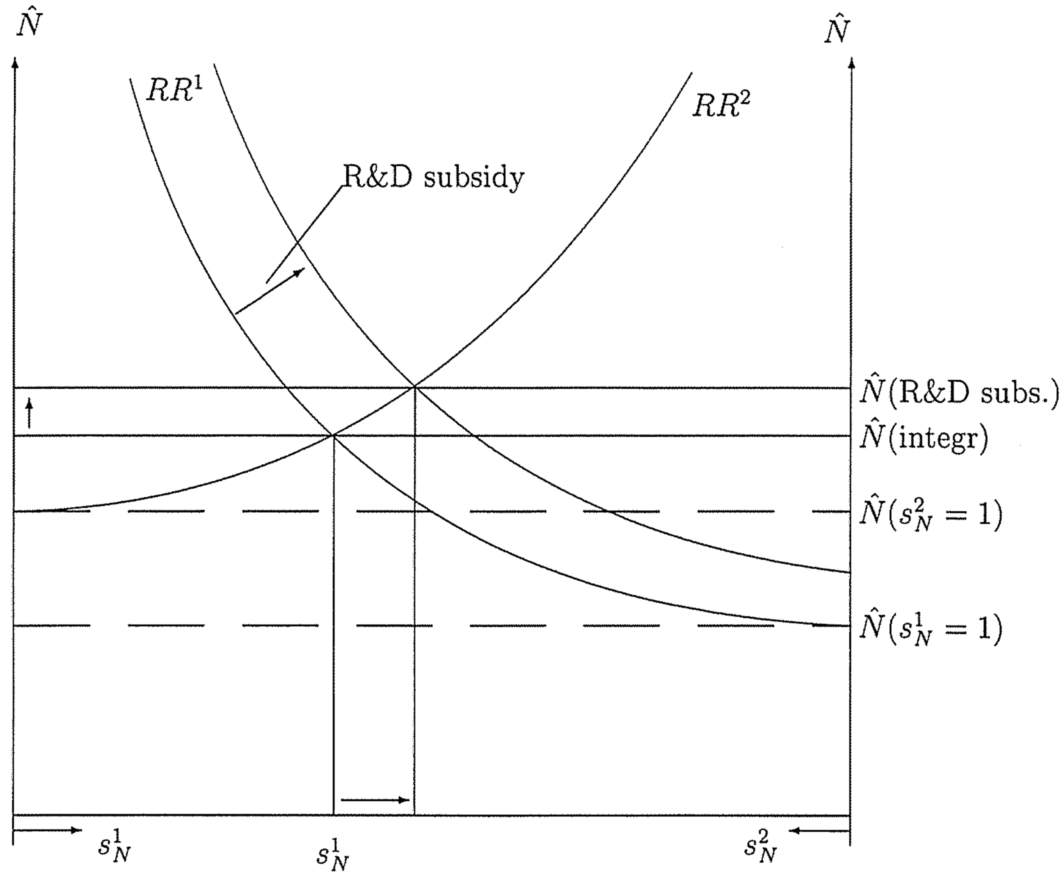

Figure 1: Innovation in the World Economy

of the resource constraints that is obtained when the government introduces either a subsidy to R&D or a subsidy to schooling. It is immediately apparent that both types of subsidies have quite similar long run effects. If the other country remains passive, the activist country is able to capture a larger share of innovative products, thus boosting the common innovation rate at home and abroad.

Ineffectiveness of Trade Policy? Perhaps somewhat surprisingly, trade policy affects neither the innovation rate nor the share of high-tech products although there will be, of course, level effects on prices and quantities. Why would protection be ineffectual in raising a country's competitiveness in the high-tech industries? Trade barriers obviously raise the domestic demand price of imported brands and induce agents to shift demand into home produced varieties. Output, prices and, due to fixed markups, unit costs rise at home. According to (14) to (16), profits and monopoly wealth rise in proportion to $\phi_x x$. If the wage for high-skilled labour were rising in proportion, $\widehat{\phi_x x} = \hat{v} = \hat{w}$, then protection would have no impact on the incentives to conduct R&D since the effects on benefits and costs would just offset each other. Similarly, higher wages would offset the increased demand of home producers for high-skilled labour, $h_x x N_{-1} = \alpha_{hx}(\phi_x x / w_H) N_{-1}$. Hence, wages rise by just enough to leave demand for high-skilled labour from production and R&D unchanged. In other words, protection raises the profitability of both manufacturing and research. By assumption, both activities compete for the same primary resource. Protection promotes both activities equally and, thus, enhances neither one, but only bids up the equilibrium wage rate.[11] However, the ineffectiveness of trade policy is a rather special result, due to the fact that both research and manufacturing of high-tech products use exactly the same primary resource. If one were to allow for a different composition of factor demand, protection would surely affect the innovation rate and the home country's share of products. Still, the magnitude of the effects might remain small as compared to policies of directly promoting training and R&D. Furthermore, we have excluded any role that trade policy might play for the international dissemination of knowledge. We have assumed at the outset that the results of industrial innovation spill over to the international economy instantaneously and completely. Thus, trade policy has no role to play in facilitating access to the international knowledge stock.

4 Calibration to Western and CEEC Countries

We now procede with a numerical implementation of this model towards the kind of numerical thought experiment outlined in the introduction. We only sketch the general procedure as much as necessary to understand the subsequent results, and relegate further details to the appendix at the end. Our approach assumes that the CEECs have successfully completed *transformation* to market economies of the Western European type, so that the above model fits equally well to both the Western countries and the CEECs. Moreover, our basic premise is that the CEECs would be in a situation broadly comparable to West European countries today, if they had a capitalistic history in a Pan-European economy instead of their communist past. On a fundamental level, this does not appear to be wholly unreasonable. After all, the stark separation of Europe that has characterized our perception up to 1990 did emerge primarily because of differences in the economic system.[12] What we now try to do is calibrate our two-region model to such a hypothetical Pan-European economy without any communist past. In doing so, we assume a laissez faire world. A suitable adjustment of key stock variables is then meant to reflect the unfavourable initial conditions that the communist past has in fact donated to the CEECs. This allows us to calculate *transition paths*. We first calculate a laissez faire transition path which we then compare with adjustment under certain policy interventions.

The calibration procedure detailed in the appendix requires data on regional GDPs, flows of fixed capital formation, capital income shares, the structure of intra-industry trade between the two regions, the overall trade balance, as well as the size and breakdown (into high- and low-skilled) of each region's labour force. Among the key parameters to be specified exogenously are the real interest rate, the growth rate of wages, the elasticity of substitution between different varieties of the high-tech good (or, equivalently, the markup for these goods), the intertemporal elasticity of substitution, and an adjustment cost parameter for investment in physical capital. In line with our basic premise, we largely rely on observed data for the West European economies and use these, together with observations on the CEECs where available, to infer hypothetical data for the CEECs. For instance, we take the observed ratio of high- to low-skilled labour for Western countries and apply this to the observed overall labour force of the CEECs, to obtain the size of high- and low-skilled labour endowment of the CEECs. In a similar vein, the CEECs' GDP is obtained by applying the observed average labour productivity of West European countries to the CEECs' total labour force. The ratio of fixed capital formation to absorption as well as the capital income share are similarly taken from Western observations and assumed to hold for both regions in the benchmark equilibrium.

Perhaps the most difficult part of arriving at a meaningful stylized data set relates to trade flows. It might be tempting to just look at Western European countries' external trade position (i.e., trade with non-European countries) to infer what trade between Western Europe and the CEECs might look like in the hypothetical Pan-European benchmark equilibrium. There are, however, several problems with this which led us to follow a different procedure. First, overall external trade of Western Europe is with countries that are quite different from our hypothetical 'non-communist' CEECs, both in terms of the degree of integration and in terms of structural characteristics. Secondly, the present volume of West-European trade with the CEECs is way below its full post-transformation potential, as revealed by several empirical studies [see the survey by Baldwin (1994, p. 102)]. And thirdly, any aggregation from some given commodity classification to our two-dimensional commodity space would appear to be highly arbitrary, and depending on where one would draw the line between high- and low-tech goods, the calibrated structure of productin could be quite different (and sometimes implausible). We therefore decided to resort to theoretical reasoning instead of trade statistics to arrive at the trade pattern of our two-region Pan-European economy. In a world with identical and homothetic tastes, the share of high-tech exports in country 1's GDP is equal to the ratio of the other counry's absorption in world-GDP, $s_D^2 = \bar{P}^2\bar{D}^2/(\mathrm{GDP}^1 + \mathrm{GDP}^2)$, multiplied by the share of this commodity in domestic production, $s_X^1 = N_{-1}^1 p_x^1 x^1/\mathrm{GDP}^1$.[13] Thus,

$$\frac{N_{-1}^1 p_x^1 (x^1 - D_x^{11})}{\mathrm{GDP}^1} = s_D^2 s_X^1, \tag{28}$$

and analogously for the second region. The basic idea simply is to use s_D^i and s_X^i together with GDP data to infer exports of high-tech goods (the numerator of the l.h.s. above). We assume balanced trade between the two regions for our benchmark growth path, hence s_D^i coincides with the ratio of region-i- to world-GDP. The justification is twofold. First, if measured in percent of GDP, the observable deviation of absorption from GDP is very small for the group of Western countries as a whole (with an external surplus on goods *and services* of about 1 percent of GDP in 1990, according to UN data).[14] Secondly, and more importantly, our benchmark growth path is a hypothetical construct with a very tenuous relationship to the present historical situation, in particular as regards aggregate trade balance. Hence, given GDP-values obtained as mentioned above, all we need are reasonable figures for production shares in GDP to arrive at the high-tech trade figures that we require for calibration. By definition, $s_D^1\text{GDP}^2 = s_D^2\text{GDP}^1$, and the production shares are equal in both regions if and only if intra-industry trade in high-tech goods is balanced, i.e., if there is no inter-industry trade at all. In line with widely held expectations, we assume that the West continues to hold a comparative advantage in high-tech goods vis à vis post-transformation CEECs, and therefore is a net-importer of standardized goods from the East in our benchmark equilibrium. We thus assume a larger production share of high-tech goods for the West (80 percent) than for the East (60 percent). More details on data sources are given in the appendix at the end where tables A.1 and A.2 give an overview of the values chosen for the various parameters and the calibration results obtained.

5 Transition Path

Starting from a path of balanced growth for our hypothetical Pan-European economy, we now introduce history by changing the initial conditions. Instead of being on this reference path, the CEECs start out with lower capital stocks, both physical and human. Moreover, reflecting a rather poor innovation record during their communist past, the degree of product diversity and the number of 'blueprints' available in the CEECs is assumed to fall short of its reference value by a significant amount. As with capital, the number of high-tech goods produced by CEECs must be seen as a stock variable which can only adjust through R&D which requires time and resources.

Initial Conditions: The extent to which the actual starting point of transition deviates from the benchmark balanced growth path must be approximated by relying on indicative information rather than hard facts. Thus, looking into UN trade data and WIIW (1995), we observe that the (weighted) average ratio of high-tech exports (defined as SITC 5-9) to GDP for the West is more than twice the ratio of high-tech exports of the East to the West. In terms of our model, this must to a large extent be attributed to a much lower degree of product differentiation. We therefore scale down the *number of brands* produced by the East to half its benchmark balanced growth value. Turning to the physical capital stock, one might look at the observed differences in labour productivity between West and East to infer the extent to which the Eastern physical capital stock deviates from its hypothetical balanced growth value. However, our data reveal that Eastern labour productivity is but a third of Western productivity, and taking any sensible value for the elasticity of output with respect to capital, this would amount to an enormous deviation. In their investigation of German unification, Sinn and Sinn (1992) suggest that the East German capital stock was devalued to about a third of its book value upon unification. This is based on a direct confrontation with the West German economy. In our two-region model economy, the effect would appear to be somewhat more moderate, and it is certainly uneven across sectors. We therefore assume a 50 percent gap for *physical capital* in the differentiated goods sector, and a 30 percent gap for the standardized goods sector. Our *human capital stock* largely relates to engineering knowledge. It is quite well known that Eastern countries do not lag behind as much in this regard as they do in terms of institutional knowledge. Hence, we assume a more modest lag in the amount of 10 percent.

Starting from different initial conditions may, under certain assumptions, give rise to permanent effects in the sense of leading to a different steady-state level position, not only for the CEECs, but also for Western European countries. Thus, our model exhibits path dependence in terms of levels, but not in terms of growth rates. In other words, starting out with grossly displaced initial conditions implies that East and West will permanently experience growth paths that are different in terms of *levels* from the hypothetical case of a 'non-communist history'. Long-run growth rates remain unaffected by initial conditions, but may be influenced by policy intervention (see below). With the help of our calibrated model, we now propose to quantify the implications of this difference in initial conditions. We first present the transition path emerging for a laissez faire world. And in the following section, we proceed to evaluate alternative ways of influencing transition by means of policy intervention, using the laissez faire transition path as a reference case.

Physical Capital: Table 1 gives percentage deviations for various selected periods between laissez faire transition and the benchmark path of a Pan-European economy without a communist history in the East. To obtain a better intuition for the catching-up process, we decompose the displacement of initial conditions. Part (a) turns to the fact that the East starts with a largely obsolete capital stock. Quite obviously, output and income must be very low as compared to the long-run potential. Scarce capital depresses labour productivity and wages. Since the gap in the capital stock is more pronounced in the advanced X-sector, high-skilled labour suffers from particularly strong wage pressure in the early transition phase, while the returns to capital should be large. This implies a more moderate wage spread early on as compared to the long-run situation after the catching-up process. Large capital investments in the high-tech sector will also lead to wage increases for skilled labour. The prospect of relatively high wages in the future provides incentives for increased education. The effective supply of high-skilled labour is, therefore, relatively low in the short run since agents spend more time in school in order to acquire skills and supply less factory work. This puts an obstacle to the expansion of all skill intensive activities. However, the brunt of adjustment is borne by the high-tech sector as employment will actually shift to R&D where labour productivity is largely untainted. The output contraction in the high-tech sector strengthens prices, improving both the terms of trade and monopoly profits and thus the rewards to R&D, while the erosion of high-skilled wages saves research costs. Consequently, the speed of innovation picks up. Since the model abstracts from the use of physical capital in R&D, low initial capital stocks may thus indirectly favour product development. However, all of these are temporary phenomena. Once investment succeeds in closing the large initial gap in capital stocks, wage growth slows down to a more moderate speed in the long run, thus weakening education incentives. Both the schooling and reallocation effects disappear. Indeed, the medium-run surge in innovative activities in the East is not sustained in the long run when diversity actually falls short of the undisturbed growth path. The most important and, indeed, the only significant long-run implication of initial capital shortage relates to foreign sector accounts. The CEECs accumulate a heavy debt position that must be serviced by returning to a trade surplus in the long run. Starting from depressed initial conditions, these countries should see rapid income growth during the catching-up period. The intertemporal consumption smoothing motive implies that agents want to borrow against future income increases by going into debt abroad. The size of the foreign debt, of course, reflects the absence of any credit market imperfections and uncertainty about the future. In our model, countries have unlimited access to international capital markets as long as they satisfy intertemporal solvency conditions. In reality, however, access to international capital markets may be rather restricted, so that our results should be seen as an upper bound.

Human Capital: Part (b) of table 1 turns to human capital where the initial gap is a relatively modest ten percent. A lower overall supply of skills is felt in a higher wage per unit of skills (see the impact effect on the wage spread), but the opportunity cost of schooling ($w_H H_{-1}$) is nonetheless reduced. Weighing this cost against the present value of future income gains from additional education, agents decide to withdraw some of their time from factory work. As a result, the initial gap in the *effective* human capital stock is almost double the initial skill displacement. The CEECs cut back on high-tech manufacturing and innovation since these activities are particularly skill intensive. A smaller menue of specialized products depresses productivity and raises the acquisition price for capital. Investment incentives are further dampened by the skilled labour shortage which depresses the marginal productivity of capital in the X-sector where short-run investment is particularly low. The severe medium-run contraction of high-tech output is reflected by a deterioration of the high-tech trade balance. Over the course of time, the CEECs will accumulate a significant foreign debt burden. Once they succeed to close the skill-gap, innovation and manufacturing pick up and the economy rebounds. However, capital stocks and the product range permanently remain below what they could have been if the CEECs had started out with initial conditions comparable to developed Western economies (the hypothetical benchmark case).

Knowledge Stock: A further aspect of the 'communist legacy' relates to product diversification and the number of blueprints for differentiated goods. Part (c) of table 1 portrays the transition following a fifty percent initial gap in the product range. Less product diversity implies a lower productivity of forming capital goods and depresses investment incentives. Furthermore, a smaller knowledge stock retards the development of new variations of sophisticated goods. Thus, the transition suffers from low physical capital stocks which restricts production of both goods. However, contraction is much more severe in high-tech manufacturing. In the early adjustment phase the CEECs are catching up in the research sector, creating a shortage of high-skilled labour. With a high wage rate today, the opportunity cost of education is high. Agents cut back on their schooling activities and devote more time to working which eases the skilled labour shortage somewhat. Nevertheless, the innovation boom diverts high-skilled labour from skill intensive manufacturing. High-tech production falls by more than 20 percent on impact when capital stocks are still on their benchmark levels. Later on when innovation returns to a more normal speed, wages for skilled labour yield somewhat as labour is released from research activities. The output decline in skill intensive manufacturing is reversed to a large degree, but not completely. Since the initial gap in the product range is as much as 50 percent, output per firm in the EAST must be much higher in these early phases of transition and prices of Eastern varieties therefore lower. The marked deterioration in the terms of trade also feeds into a large deterioration of the high-tech trade balance, while the trade balance in Y-goods actually increases vis à vis the benchmark situation since there is no immediate contraction of output.

To complete the picture, part (d) of table 1 gives a flavour of how transition might look like if all the initial gaps hold simultaneously. We may abstain from further explanations since we have already discussed the individual components of the transition scenario. Figures 1.a through 1.d allow for a convenient visual inspection of transition paths for key variables. Solid lines relate to the overall scenario while broken lines show the decomposition. The figures also reveal that the catching-up process will never be complete if the scenario includes a displacement of Eastern knowledge stock and, thereby, implicitly of the world knowledge stock. As is clear from the analsysis of section 3, the model does not endogenously determine the long-run level of the world knowledge stock. It depends on its own initial condition and the developments during the transition. However, the model uniquely determines the long-run growth rates, interest rate, and also the *ratios* of capital stocks and country specific knowledge stocks *relative* to the worldwide knowledge stock. Figure 1.a shows that X-sector capital almost completely catches up if only its own initial condition is displaced (bold triangles). On the other hand, X-sector capital fails to converge back to the original growth path if the initial condition of either human capital or the Eastern knowledge stock are subject to an initial disturbance. In both cases the innovations during the transition result in a permanently lower path of worldwide knowledge stocks. The argument is particularly clear from figure 1.c where the initial displacement of Eastern (and, thus, worldwide) knowledge capital cannot be made up for by the innovation during the transition. In short, the long-run income levels depend on what happens to innovation during the transition.

6 The Role of Policy

It is hard to perceive transition without any government policy. Indeed, successful transition is widely regarded as a matter of choosing the right policies, and it appears that transition economies are major attractions for economic policy advice. From the viewpoint of the neoclassical efficiency paradigm, policy needs to identify and correct market failures that may cause inefficiency along the adjustment path. In principle, such inefficiencies may be avoided and targeted by means of an appropriate corrective policy instrument. Unfavourable initial conditions that are inherited from history are a matter of fact and, thus, unavoidable. Indeed, one of the principal messages from our results is that detrimental initial conditions do not, per se, provide any rationale for active government policy. Quite to the contrary, distortionary policies already in place may be important sources of inefficiencies. For example, trade between East and West is still heavily hampered by artificial tariff and non-tariff barriers which are well known to cause static inefficiencies and are widely regarded as being detrimental to the transition process. Under certain conditions, trade policies may also influence the long-run growth performance even though we have ruled out such implications by construction of our model (see above). It is nonetheless interesting to explore the role that commercial policy may play in our numeric calculations.

More fundamental distortions that we highlight in our model relate to R&D and high-tech manufacturing production. Product differentiation and monopolistic competition result in prices above marginal cost in the high-tech sector. Moreover, individual innovators produce knowledge spillovers to the rest of the economy. This positive externality is not rewarded by market prices, thus makes private agents hesitant to invest in research and implies a lower than optimal rate of innovation.[15] Grossman and Helpman (1991) identify an R&D subsidy as a first best policy to close the gap between the social and private returns to R&D. We investigate how transition might be affected by such a policy. Finally, given the importance of human capital in industrial research as well as technologically sophisticated production, one might wonder if there is a case for subsidizing education. We therefore include a schooling subsidy in our policy scenarios. Tables 2 and 3 juxtapose the effects of these policies on the transition paths and the panels in figure 2 provide a concise visualization.

The preceding section demonstrated a catching-up scenario of an economy that starts from unfavourable initial conditions. Table 1 and figure 1 reported the transition in terms of deviations from a hypothetical balanced growth equilibrium which is indicated by the broken horizontal line in figure 1. Once the historical stock variables are displaced from the steady state path, path dependence in levels may prevent the economy from ever again reaching the same long-run equilibrium path. The lines end up being horizontal because we have deflated all variables by their long-run growth rates. We have interpreted the fat solid line as discribing the laissez faire transition path. We now shift our viewpoint and take this as our reference equilibrium. We ask how policy may cause the economy to follow an alternative path of development that moderately deviates from the fat solid lines of figure 1. Figure 2 and table 2 show percentage deviations from the laissez faire transition.

Trade Policy: One of the main problems in East-West integration is the resistance of Western European countries to open their markets for the labour intensive traditional Y-goods where the CEECs have a clear comparative advantage. The West continues to provide protection in these 'sensitive' sectors which, in turn, might provoke a protectionist backlash in the CEECs against high-tech skill intensive imports of X-goods from the West. We capture the essence of the problem by means of two scenarios: Panel b of table 2 shows how the East is affected if its exports to the West are discriminated against by a ten percent tariff. Panel a shows some effects on the EAST if it slashes a ten percent tariff on high-tech skill intensive imports from Western Europe. In both scenarios, the tariff measures are unilateral. For lack of space we report results only for the East which is identified as region 1.

Western protection against labour intensive goods from the East reduces demand for the traditional good. The relative price of high-tech goods must increase, and more so in the West than in the East. Since the price of the import good in the East is p_x^2 while its export prices are p_x^1 and $p_Y = 1$, the terms of trade may be identified by the change in p_x^1/p_x^2. Consequently, the terms of trade move against the East, after some periods at least. On the other hand, it also produces the skill intensive innovative good which now sells at a price relatively higher than the traditional good. The prices of skilled labour and the rental price of X-sector capital rise since these factors are used in the high-tech industry. By the same reasoning, wages for the unskilled and the rental price of Y-sector capital must fall. Since both sectors purchase the same capital good, the increased rental rate of return in the X-sector boosts capital accumulation, while investment in the Y-sector is depressed. Higher future wages for high-skilled workers boost the returns to education and expand skilled labour supply after a few periods. Such a shift in factor supplies clearly favours the expansion of the Eastern high-tech sector but shrinks its traditional sector. The East therefore generates a smaller trade surplus in Y-goods but also relies less on net imports of the innovative good (note that the X-sector trade balance is negative in the base case transition). Obviously, the decline in export earnings also translates into higher foreign debt. Table 3 shows that Western protection inflicts welfare losses on the East. The terms of trade deterioration importantly contributes to these losses.

If the CEECs were to slash tariffs against skill intensive Western high-tech imports, producer prices of innovative goods p_x^1 would rise in the East while declining export demand would erode prices p_x^2 in the West. Nevertheless, tariffs raise the demand prices of Western high-tech imports in the East and inflate the acquisition costs of the composite capital good. Investment conditions deteriorate relative to the base case transition. Since relative output prices move in favour of X-manufacturing, the decline in capital investments is more pronounced in the traditional Y-sector. On impact, a higher producer price p_x^1 boosts wages for high-skilled labour but eventually this effect is reversed as the lack of investment shrinks the capital stock. With a high opportunity cost today and low returns in the future, agents cut labour training and spend more time working in the factory instead. Consequently, the effective supply of high-skilled labour first expands before it contracts later on. These changes in factor supplies explain the short-run expansion followed by a contraction after some periods due to lower capital investments. Intuitively, as demand shifts away from imports towards home produced high-tech goods and towards the traditional good, and as aggregate output of the X-sector first expands before it contracts, the trade balance must improve quite vigorously in the short-run. Over time, the improvement becomes more moderate. The trade surplus in traditional goods shrinks monotonically. Panel a in table 2 reports the real trade balance. The increase in export prices gives even more weight to the improvement in the X-sector trade balance and explains why the net foreign asset position improves. The reduction in Eastern foreign indebtedness may also be viewed from a savings investment perspective. As agents anticipate the reduction in future income, they reduce consumption today and save more (consumption smoothing). The home economy also needs to finance less investment and, thus, relies less on foreign capital inflows. Finally, the East improves its welfare position (see table 3) which may be largely explained by a terms of trade improvement. Western high-tech goods are the only imports of the Eastern economy. Thus, import prices fall relative to export prices for traditional goods and Eastern brands of the sophisticated good.

R&D Subsidy: The subsidy directly addresses the incentives for industrial innovation by reducing private research costs. As derived in our theoretical investigation, the common world innovation rate increases and the East captures a larger share of world production of innovative goods. More rapid innovation pushes up the interest rate as well as wage growth. From table 3 we learn that the rise in the interest factor exceeds the change in wage growth to the effect that the present value of future wages shrinks. Consequently, the incentives for labour training are diminished. High-skilled agents redirect their activities from schooling to working in high-tech production or research labs. Therefore, the effective supply of skilled labour expands in the short-run, but is retarded once the skills deteriorate due to neglected labour training. Despite of this favourable short-run supply effect, skill intensive manufacturing actually declines. High-skilled labour is released from manufacturing to accommodate the demand of a booming innovation sector. The productivity effect from the introduction of new specialized varieties reduces the resource cost per unit of capital. Capital becomes cheaper which eventually attracts more investment to both production sectors and accommodates a slow revival of manufacturing outputs. The growth effects are visualized in panels c and d of figure 2. Since all variables are deflated by their *initial* growth rates, more rapid growth after policy intervention tilts the time paths upwards into the future. Finally, table 3 shows that an R&D subsidy yields welfare gains which stem from two readily identified sources. First, the terms of trade change in favour of the East. The redirection of skilled labour towards innovation creates a supply shortage of the skill-intensive good in the East and raises the terms of trade in the X-sector, see table 2 c. In addition, more rapid innovation makes prices of high-tech goods fall faster in both regions and decline relative to basic Y-goods. Since the East is a *net* importer of high-tech goods but exports the basic good, it benefits from a dynamic terms of trade effect over time. A second channel for welfare gains is the fact that the R&D subsidy addresses a market failure which causes a suboptimally low innovation rate. A policy that accelerates innovation therefore yields first order welfare gains on that account.

Education Subsidy: The long-run consequences of an education subsidy are quite clear cut and have already been discussed in the theoretical section. The general skill level and the effective supply of skilled labour expand in the long-run and encourage both innovation and high-tech production. The most striking aspect of this scenario is to demonstrate the possibility that things may get dramatically worse before they turn to the better. In the short-run, a considerable part of skilled labour is withdrawn from the active labour market, as agents respond to education incentives and spend more time on schooling. The skilled labour shortage strongly inhibits industrial research and, to a somewhat lesser extent, skill intensive production. Once the skill upgrading in response to education incentives are completed, the shortage turns into a skilled labour abundance that boosts innovation and high-tech manufacturing. Eventually, the available product diversity surpasses its laissez faire value. The resulting productivity effects cut into investment costs and boost capital accumulation which further expands production. Figure 2 demonstrates this dynamic adjustment pattern. Education shifts income into the future. In anticipation of future riches, agents spend on consumption already now and reduce their savings. Consequently, domestic expenditure is partly financed by additional indebtedness abroad. The welfare implication of supporting education is not encouraging. The reason is that schooling decisions of private agents correctly respond to market incentives. Rather than addressing an existing market failure, the subsidy introduces a new distortion between training and production activities. While the education policy boosts the long-run growth rate and, thus, indirectly alleviates the R&D insufficiency, it does so by sacrificing output in the short-run. Table 3 reports a non-negligible welfare loss.

7 Conclusions

In this paper, we have attempted to provide a quantitative treatment of the catching-up process that the Central and Eastern European Countries (CEECs) will experience once they have completed their transformation to market economies. Based on a conceptual distinction between systemic transformation and transition, the paper focuses on transition which is identified as the dynamic adjustment following the very unfavourable initial conditions that their communist history donates to these countries. Towards this end, we have developed a two-region model of the world economy which highlights the importance of capital accumulation, both physical and human, as well as innovation for economic growth. We have characterized the equilibrium properties of such a world economy and how these may be influenced by economic policy. Economic transition is then viewed as a growth path which starts from initial conditions that are grossly displaced from a steady state path. More specifically, we assume that the CEECs start out with much less physical capital, a lower level of manufacturing and research skills, as well as a lower product range than would be the case for a comparable Western-type economy. By relying on numerical techniques we were able to pin down several important details of these transition paths. Moreover, we have compared the kind of transition emerging in a laissez faire world with policy-influenced adjustment paths. The policies considered are tariff protection (by the CEECs themselves or the West), as well as growth oriented policies such as an R&D subsidy or an educational subsidy.

One of the conclusions of this thought experiment is that, even if systemic transformation should go perfectly well, the time horizon of catching-up is rather long. For instance, it may take more than four decades until transition economies reach their steady state levels of physical capital stocks. The time horizon comes close to the economic life-span of a generation. Not only does it take a long period of time, but catching-up may also be incomplete. Detrimental initial conditions may have permanent effects. Our experiment shows that both physical capital and knowledge capital remain persistently below what they could have been without the unfortunate starting conditions donated by the centrally planned economies. The long-run gaps are quite substantial - more than 15 percent in the case of blueprints and more than 5 percent in the case of human capital. A further aspect of the catching-up process is the unprecedented long-run levels of foreign debt. Our solutions may be seen as an upper bound for the borrowing requirements if these countries had unrestricted access to perfect international capital markets at a moderate interest rate. Our model does, of course, impose the condition that transition countries remain solvent and are in fact able to service the accumulated debt.

Transition is significantly affected by policies towards research and human capital accumulation, as well as by trade policies. We did not allow any influence of trade policy on the long-run growth rate, but protectionist policies nevertheless have important level effects. Our calculations show that the continued import protection against labour intensive goods by Western countries inflicts a welfare loss on the CEECs. The CEECs might be tempted to retaliate by discriminating against high-tech imports from the West. Even absent retaliatory forces, such protection is sometimes advocated along the lines of an infant-industry argument. Our results reveal that the CEECs may, indeed, harvest a moderate welfare gain through such a trade policy. This is largely due to the familiar terms of trade effect.

Whether or not an active policy towards innovation or skill formation leads to a preferable transition path depends on the externalities that may be present in these activities. Our model captures such externalities in the form of knowledge spill-overs. An R&D subsidy therefore gives rise to a positive welfare effect through more rapid product development along the transition. Moreover, such a policy also affects the long-run allocation of resources between R&D and manufacturing and, therefore, the long-run growth rate. However, for a 10 percent subsidy the magnitude of the welfare and long-run growth effects are less than impressive. An educational subsidy will likewise raise the long-run growth rate by a moderate amount, but only at the cost of quite sizable short-run output losses. Even though it helps to boost innovation which is inefficiently low due to knowledge spillovers, the model does not allow for a similar externality in the education decision. Rather than addressing an existing market failure, the subsidy introduces a new distortion and, thus, imposes a considerable welfare loss.

Notes

1. Throughout this paper, 'Western' and 'West European' are used synonymously.

2. To avoid cluttered notation, we suppress time and country indices whenever possible without confusion. An undated variable such as N refers to the current period while N_{-1} refers to the previous period. When necessary, superindices 1 and 2 identify the home and foreign economies.

3. For a model in which the composition of the labour force responds to the wage spread, see Keuschnigg (1996).

4. The main text focusses on some analytical results and, thus, specializes to the logarithmic case with $\gamma = 1$. The simulation model implements the more general case. A detailed treatment of this case is described in a separate appendix which is available upon request.

5. Further details may again be found in the separate appendix.

6. The same type of investment problem applies in each sector at home and abroad. At this stage, we suppress country and sector indices.

7. The computational model incorporates trade barriers also in the traditional good.

8. Notice that any increase in the number of varieties affects the acquisition price for the capital good, thus raising the productivity of investment. In Keuschnigg and Kohler (1995a), we show how this may give rise to an investment multiplier if the introduction of new goods in turn relies on physical capital.

9. If capital could be costlessly transferred across sectors but not across countries, one would be left with a consolidated country specific resource constraint, $\zeta_K^i = k_y^i Y^i + k_x^i x^i N_{-1}^i - K_{-1}^i$.

10. With $\hat{P}_Y = 1$, the consumer price index increases with $\hat{\bar{P}}^i = (\hat{P}_{\bar{X}})^{\alpha_{cx}^i}$. The cost function in the Y sector implies $\hat{w}_K^i = \hat{w}^{-\alpha_{ly}^i/\alpha_{ky}^i}$. Since the no-arbitrage relation (8) implies $\hat{w}_K^i = \hat{\bar{P}}^i$, one equates the two equations to obtain $\hat{P}_{\bar{X}} = \hat{w}^{-\alpha_{ly}^i/(\alpha_{ky}^i \alpha_{cx}^i)}$. Except for a coincidence, this cannot hold for diverging α-shares. Other cases would inevitably give rise to specialization. Note, however, that in a more general framework where both sectors use high- and low-skilled labour, only the cost share of capital needs to be

identical while the shares of the two types of labour may differ since their prices grow at a common rate.

11. Grossman and Helpman (1991, pp.66) note the same result for the effect of an output subsidy in a simplified version of the model.

12. In this connection, Baldwin (1994, p. 106) reports on an interesting observation from 1928 League of Nations statistics where Czechoslovakia was listed under 'Industrial Continental Europe', while Denmark, Spain, Norway and Finland were listed under 'Other Continental Europe'.

13. See Helpman and Krugman (1985, chapter 8) for a detailed treatment of the volume of trade in models like ours.

14. On goods alone, Western European countries exhibit an external deficit of about .7 percent of GDP.

15. This outcome is specific to the case of growth driven by horizontal product differentiation and does not necessarily carry over, for instance, to growth based on quality improvements [see Grossman and Helpman (1991)].

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Table 1: Transition in EAST – Laissez Faire

Percentage changes in periods		(1)	(10)	(30)	(100)
(a:) low initial physical capital stocks					
N_{-1}	product range	0.000	1.989	1.423	-1.129
$K_{y,-1}$	capital stock in Y-sector	-30.000	-13.966	-2.705	-0.478
$K_{x,-1}$	capital stock in X-sector	-50.000	-22.440	-2.325	-0.473
H_{-1}	skill level	0.000	1.955	0.672	-0.005
uH_{-1}	effective supply of skills	-8.451	0.961	1.076	-0.006
$w_H H_{-1}/w_L$	wage spread	-2.430	0.757	0.653	0.000
xN_{-1}	output X-sector	-27.656	-9.848	-0.037	-0.183
Y	output Y-sector	-10.076	-4.380	-0.813	-0.143
p_x^1/p_x^2	terms of trade	10.289	3.632	0.465	-0.001
TB_Y	trade balance Y-sector *)	-6.612	-1.535	1.593	2.145
TB_X	trade balance X-sector *)	-12.991	-2.081	3.953	3.050
B_{-1}	net foreign asset position **)	0.000	-74.058	-101.046	-95.901
(b:) low initial human capital stock					
N_{-1}	product range	0.000	-10.393	-5.985	-5.339
$K_{y,-1}$	capital stock in Y-sector	0.000	-0.703	-1.698	-2.264
$K_{x,-1}$	capital stock in X-sector	0.000	-4.404	-3.571	-2.262
H_{-1}	skill level	-10.000	-4.358	-0.647	0.000
uH_{-1}	effective supply of skills	-18.213	-7.166	-1.217	0.000
$w_H H_{-1}/w_L$	wage spread	-6.650	-2.521	-0.487	0.001
xN_{-1}	output X-sector	-2.871	-6.774	-2.388	-0.865
Y	output Y-sector	0.000	-0.210	-0.509	-0.680
p_x^1/p_x^2	terms of trade	0.529	-0.853	0.079	0.000
TB_Y	trade balance Y-sector *)	1.809	1.489	0.987	0.909
TB_X	trade balance X-sector *)	1.690	-4.239	0.137	1.558
B_{-1}	net foreign asset position **)	0.000	-10.434	-39.169	-45.872
(c:) low initial product range					
N_{-1}	product range	-50.000	-14.518	-10.519	-10.070
$K_{y,-1}$	capital stock in Y-sector	0.000	-2.205	-3.890	-4.343
$K_{x,-1}$	capital stock in X-sector	0.000	-4.888	-4.585	-4.342
H_{-1}	skill level	0.000	-0.757	0.004	0.002
uH_{-1}	effective supply of skills	6.988	-1.359	-0.124	0.002
$w_H H_{-1}/w_L$	wage spread	5.251	-0.595	-0.118	0.000
xN_{-1}	output X-sector	-21.053	-4.272	-1.953	-1.671
Y	output Y-sector	0.000	-0.662	-1.175	-1.313
p_x^1/p_x^2	terms of trade	-10.999	-0.433	0.071	-0.000
TB_Y	trade balance Y-sector *)	2.725	1.486	1.218	1.187
TB_X	trade balance X-sector *)	-27.958	-1.395	1.779	2.210
B_{-1}	net foreign asset position **)	0.000	-49.071	-61.885	-63.485

Table 1 continued

Percentage changes in periods		(1)	(10)	(30)	(100)
	(d:) overall initial conditions (a+b+c)				
N_{-1}	product range	-50.000	-22.602	-14.555	-15.681
$K_{y,-1}$	capital stock in Y-sector	-30.000	-16.329	-8.019	-6.886
$K_{x,-1}$	capital stock in X-sector	-50.000	-30.426	-10.193	-6.878
H_{-1}	skill level	-10.000	-3.169	0.077	-0.003
uH_{-1}	effective supply of skills	-18.713	-7.748	-0.219	-0.003
$w_H H_{-1}/w_L$	wage spread	-4.253	-2.510	0.046	0.002
xN_{-1}	output X-sector	-45.008	-20.428	-4.334	-2.672
Y	output Y-sector	-10.076	-5.170	-2.458	-2.102
p_x^1/p_x^2	terms of trade	-1.285	2.359	0.647	-0.001
TB_Y	trade balance Y-sector *)	-2.216	1.296	3.630	4.075
TB_X	trade balance X-sector *)	-32.638	-7.751	5.552	6.547
B_{-1}	net foreign asset position **)	0.000	-125.552	-194.586	-197.644

Unstarred values indicate percentage differences vis à vis a hypothetical benchmark growth path with 'equal' initial conditions in EAST and WEST (no 'communist legacy'). *): Real trade balance, difference to benchmark expressed in percent of benchmark sectoral outputs. **): In percent of benchmark GDP.

Table 2: Transition in EAST with Policy Intervention

Percentage changes in periods		(1)	(10)	(30)	(100)
(a:) ten percent tariff on high-tech imports in the EAST					
N_{-1}	product range	0.000	-0.126	0.031	0.218
$K_{y,-1}$	capital stock in Y-sector	0.000	-3.785	-5.589	-5.859
$K_{x,-1}$	capital stock in X-sector	0.000	-3.485	-4.931	-5.052
H_{-1}	skill level	0.000	-0.075	0.003	0.000
uH_{-1}	effective supply of skills	0.507	-0.091	-0.021	0.001
$w_H H_{-1}/w_L$	wage spread	-0.114	0.452	0.805	0.858
xN_{-1}	output X-sector	0.387	-1.337	-1.936	-1.950
Y	output Y-sector	0.000	-1.142	-1.698	-1.782
p_x^1/p_x^2	terms of trade	2.124	2.561	2.698	2.699
TB_Y	trade balance Y-sector *)	-3.389	-4.301	-4.699	-4.741
TB_X	trade balance X-sector *)	7.828	3.951	2.631	2.618
B_{-1}	net foreign debt **)	0.000	9.664	12.491	12.450
(b:) ten percent tariff on standardized good in the WEST					
N_{-1}	product range	0.000	0.092	0.113	0.000
$K_{y,-1}$	capital stock in Y-sector	0.000	-4.407	-6.509	-6.785
$K_{x,-1}$	capital stock in X-sector	0.000	2.265	3.272	3.275
H_{-1}	skill level	0.000	0.136	0.050	-0.000
uH_{-1}	effective supply of skills	-0.669	0.064	0.073	0.000
$w_H H_{-1}/w_L$	wage spread	8.157	9.957	10.732	10.793
xN_{-1}	output X-sector	-0.451	0.794	1.286	1.232
Y	output Y-sector	0.000	-1.333	-1.984	-2.071
p_x^1/p_x^2	terms of trade	0.144	-0.248	-0.431	-0.459
TB_Y	trade balance Y-sector *)	-3.423	-4.649	-5.200	-5.257
TB_X	trade balance X-sector *)	5.716	4.498	4.299	4.213
B_{-1}	net foreign debt **)	0.000	-9.640	-12.580	-11.884
(c:) ten percent R&D subsidy in the EAST					
N_{-1}	product range	0.000	5.965	9.862	21.039
$K_{y,-1}$	capital stock in Y-sector	0.000	-0.216	0.145	3.960
$K_{x,-1}$	capital stock in X-sector	0.000	-0.492	0.386	4.385
H_{-1}	skill level	0.000	-0.171	-0.171	-0.229
uH_{-1}	effective supply of skills	1.106	-0.083	-0.042	-0.093
$w_H H_{-1}/w_L$	wage spread	4.644	3.969	3.986	4.000
xN_{-1}	output X-sector	-4.748	-2.918	-2.170	-0.687
Y	output Y-sector	0.000	-0.064	0.043	1.163
p_x^1/p_x^2	terms of trade	1.511	2.531	2.608	2.595
TB_Y	trade balance Y-sector *)	0.182	0.045	0.031	0.295
TB_X	trade balance X-sector *)	-1.523	0.342	0.512	0.501
B_{-1}	net foreign debt **)	0.000	-5.086	-7.549	-10.158

Table 2 continued

	(d:) ten percent educational subsidy in the EAST				
N_{-1}	product range	0.000	-9.459	-1.514	4.302
$K_{y,-1}$	capital stock in Y-sector	0.000	-0.552	-1.126	0.338
$K_{x,-1}$	capital stock in X-sector	0.000	-3.879	-0.464	3.355
H_{-1}	skill level	0.000	6.459	10.351	10.975
uH_{-1}	effective supply of skills	-19.843	-4.832	2.480	3.776
$w_H H_{-1}/w_L$	wage spread	3.519	7.659	9.676	10.170
xN_{-1}	output X-sector	-2.970	-5.790	1.020	3.605
Y	output Y-sector	0.000	-0.165	-0.337	0.101
p_x^1/p_x^2	terms of trade	0.640	-0.853	0.135	0.000
TB_Y	trade balance Y-sector *)	0.946	0.467	-0.102	-0.036
TB_X	trade balance X-sector *)	2.038	-5.121	1.302	2.903
B_{-1}	net foreign debt **)	0.000	-19.472	-52.783	-60.732

Unstarred values indicate percentage differences vis à vis the laissez-faire transition path. *): Real trade balance, difference to laissez faire transition in percent of laissez faire sectoral outputs. **): Difference in percent of laissez faire GDP.

Table 3: Welfare and Long-Run Growth Effects

Percentage change in		bench-mark	tariff EAST	tariff WEST	R&D subs.	educ. subs.
EV-EAST	equivalent variation	0.000	1.070	-0.757	1.233	-0.967
r	world interest rate	1.040	0.000	0.000	0.041	0.022
$\hat{w}$	wage growth rate	1.012	0.000	0.000	0.017	0.009
$\hat{C}$	consumption growth rate	1.041	0.000	0.000	0.056	0.030
$\hat{N}$	innovation rate	1.100	0.000	0.000	0.134	0.072

EV gives the equivalent variation implied by the respective policies for the EAST, converted into a constant flow and expressed in % of benchmark GDP. The first column gives benchmark growth rates. All other columns give percentage changes from benchmark growth rates. Thus, if if n_g is the percentage change of $\hat{N}$ for some policy, its new value is $\hat{N} \times (1 + n_g/100)$.

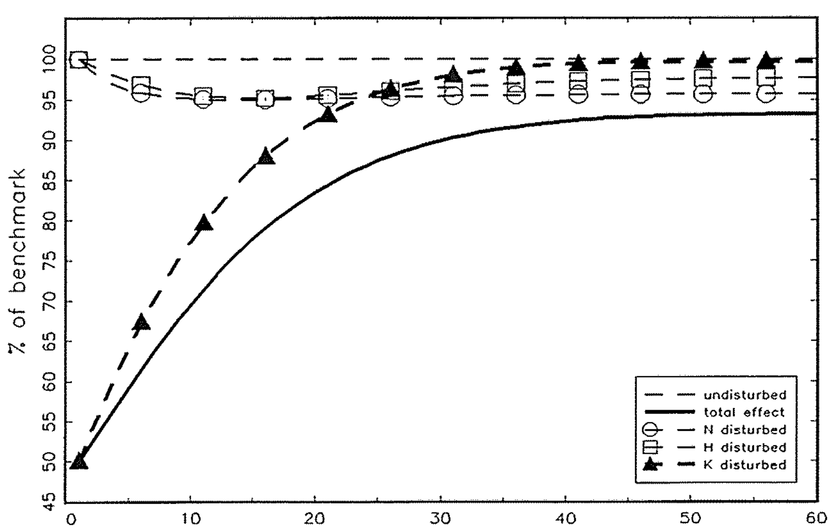

Figure 1.a: X–sector capital stock in EAST

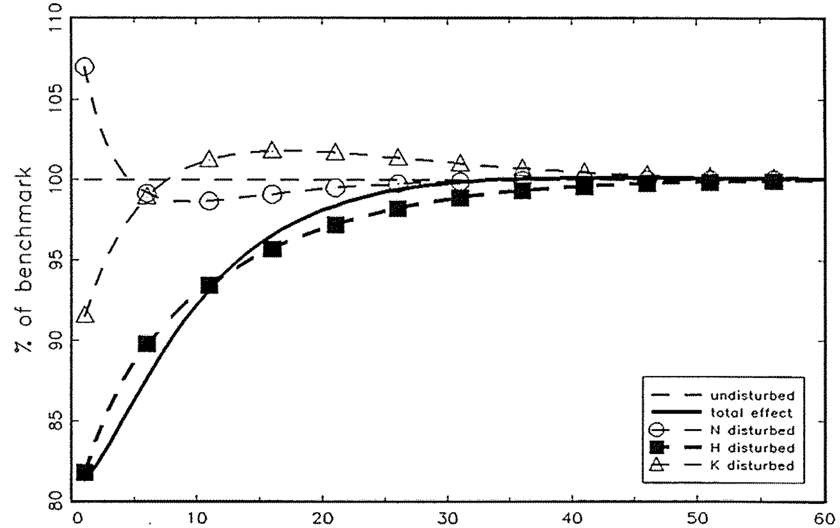

Figure 1.b: Effective human capital stock in EAST

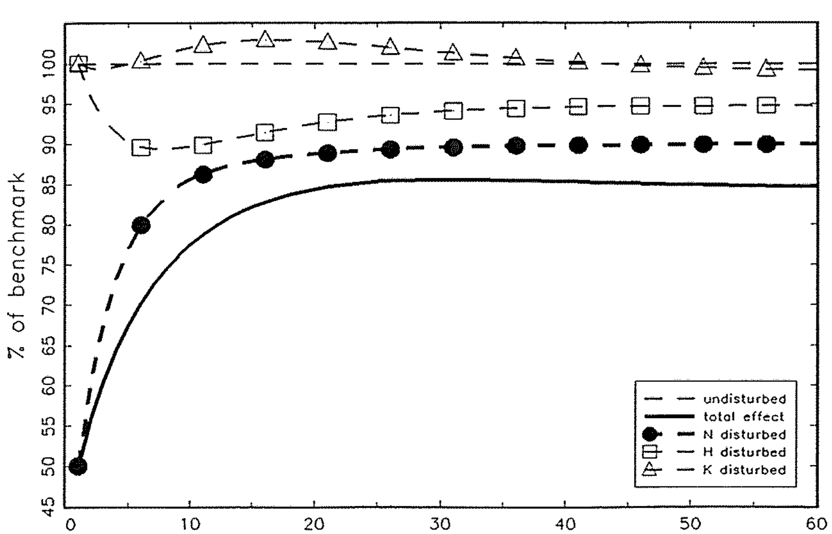

Figure 1.c: Product range in EAST

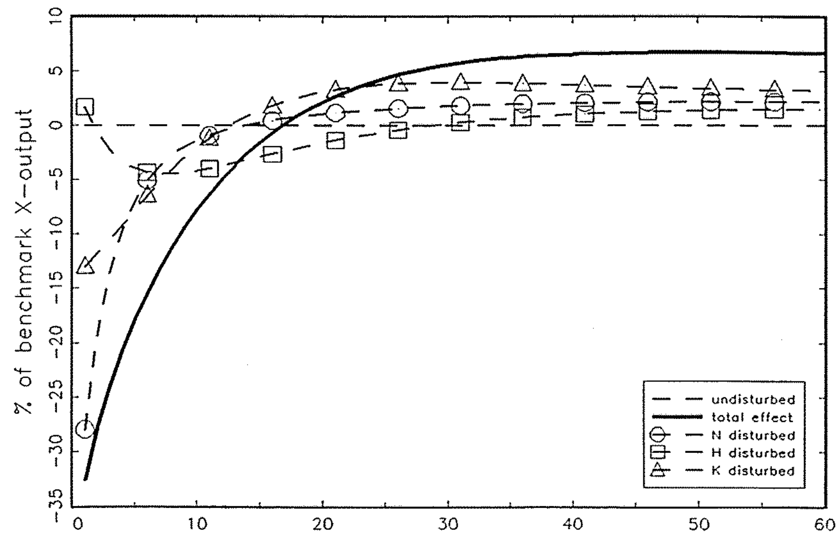

Figure 1.d: X–sector trade balance, diff. to benchmark

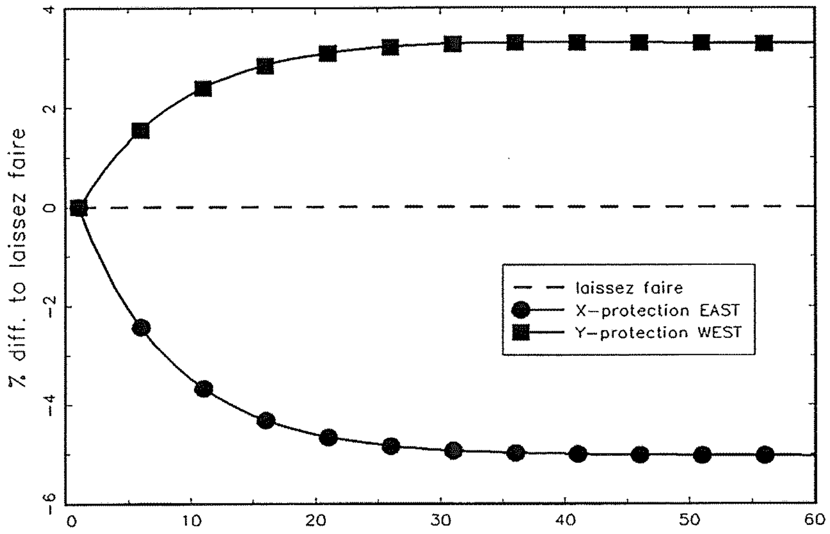

Figure 2.a: High-tech capital stock in EAST

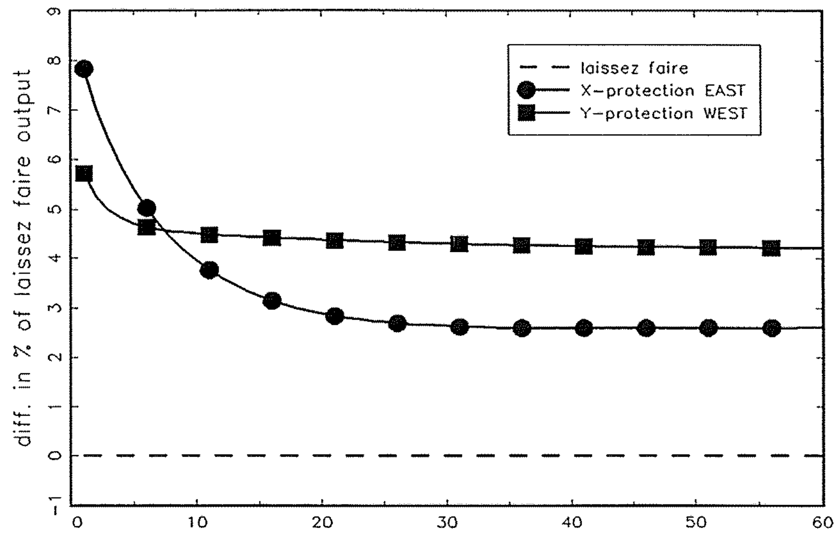

Figure 2.b: High-tech trade balance in EAST

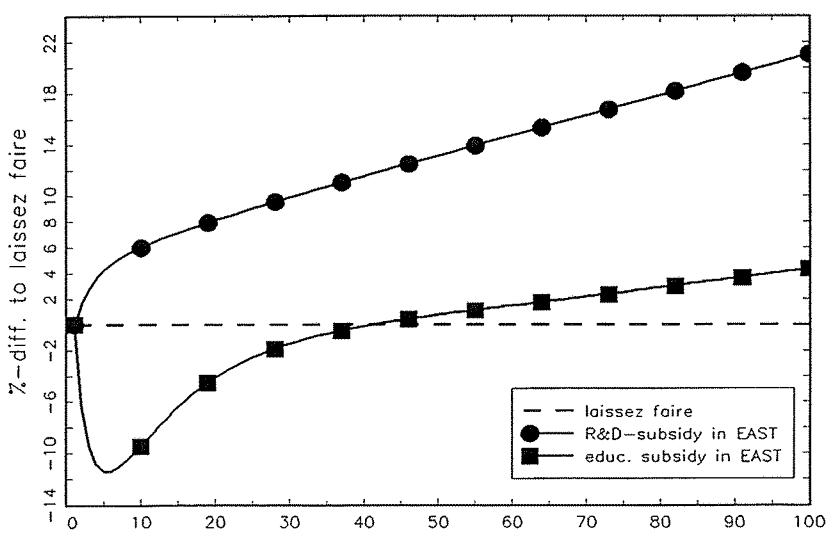

Figure 2.c: Product range in EAST

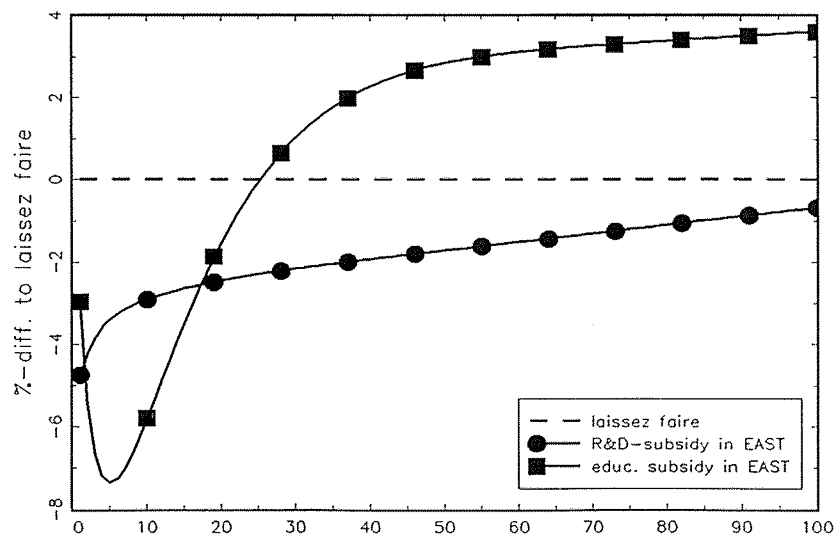

Figure 2.d: High-tech output in EAST

Appendix: More on Calibration

Calibration of such an aggregate growth model which distinguishes only between standardized goods on the one hand and differentiated high-tech goods on the other proceeds along lines rather different from the familiar case of a static multisector model. Before turning to the details of the calibration procedure we need to specify some funtional forms. Data sources will be given at the end of the appendix.

A Functional Forms

Preferences: In a number of cases, balanced growth is possible only if the elasticity of the first derivative of some function, say $u(c)$, remains constant even though the argument grows at a constant rate. For example, we require the intertemporal elasticity of substitution in consumption, $\gamma = -\frac{u'(c)}{cu''(c)}$, to be constant over time. Upon integration, one derives the most general functional form satisfying this requirement,

$$u(c) = a\left(\frac{c^{1-1/\gamma}}{1-1/\gamma}\right) + b. \qquad \text{(A.1)}$$

One may now conveniently normalize the function by choosing values for the integration constants. Since nothing hinges on the normalization of the felicity function $u(\cdot)$, we set $a = 1$ and $b = 0$.

Schooling Technology: The education technology is similarly implemented by choosing an isoelastic form with an elasticity of marginal productivity equal to $\sigma_H = -eg''(e)/g'(e)$. One may normalize and set the integration constants a and b in two alternative ways. First, one may assume that it is impossible to improve skills without spending some time in school, $g(0) = 0$. Second, at the steady-state ratio $\bar{e}$ implicitly determined by $g(\bar{e}) = 1 - \delta_H$ from (A.1f), the marginal productivity of schooling in raising skill levels is unity, $g'(\bar{e}) = 1$. This normalization implies a form

$$g(e) = (1-\delta_H)^{\sigma_H}\left(\frac{e}{1-\sigma_H}\right)^{1-\sigma_H}. \qquad \text{(A.2)}$$

It implies a stationary schooling ratio equal to $\bar{e} = (1-\delta_H)(1-\sigma_H)$ and satisfies $g(0) = 0$, $g(\bar{e}) = 1-\delta_H$ and $g'(\bar{e}) = 1$. A problem with this is, however, that a sensitivity analysis of σ_H will change the schooling ratio $\bar{e}$. An alternative normalization would be to require $\bar{e} = 1 - \delta_H$ and, therefore, $g(\bar{e}) = \bar{e}$ and $g'(\bar{e}) = 1$. In this case, one would be left with a functional form

$$g(e) = \left(\frac{1-\delta_H}{1-\sigma_H}\right)\left[\left(\frac{e}{1-\delta_H}\right)^{1-\sigma_H} - \sigma_H\right]. \qquad \text{(A.3)}$$

A drawback of this formulation, however, would be that the contribution of very small levels of educational effort to gross skill formation are negative. We therefore stick to the former alternative (A.2).

Installation Technology: We choose a quadratic form to parameterize the installation function for physical capital $\psi(i)$,

$$\psi(i) = i + \psi_0 i^2. \tag{A.4}$$

The installation function satisfies $\psi(0) = 0$ and $\psi'(0) = 1$. At a zero investment rate, a marginal unit of the capital good is transformed into a unit increase of the capital stock. With increasingly higher investment rates, the productivity of marginal investment in increasing the capital stock becomes rather low.

As a matter of experience, the computation of intertemporal equilibria is greatly facilitated by using $V = qK$ to replace the shadow price in the forward looking investment equation (B.6): $\psi'(i)\bar{P} = V/K$.[16] Replacing the current value of K by the law of motion and using the quadratic form, the investment rate is implicitly determined by

$$i^2 + \left(\delta_K + \frac{1}{2\psi_0}\right)i + \left(\delta_K - \frac{V}{\bar{P}K_{-1}}\right)\frac{1}{2\psi_0} = 0. \tag{A.5}$$

Using shorthand notation $a = \delta_K + \frac{1}{2\psi_0}$ and $b = (\delta_K - \frac{V}{\bar{P}K_{-1}})\frac{1}{2\psi_0}$, this quadratic function can be explicitely solved for the investment rate, $i_{1,2} = (-a \pm \sqrt{a^2 - 4b})/2$. We take, of course the positive root to get the investment rate.

B Fundamental Identities

To start off it is useful to repeat a few accounting identities. Denoting effective demand for the composite capital good by $\bar{\psi} = \psi(i)K_{-1}$ and the current account by $CA = B - B_{-1}$, we have

$$\begin{aligned}
&(a)\quad CA + \bar{P}\bar{\psi} + vI_N = S = (r-1)B_{-1} + w_K K_{-1} + \pi N_{-1} + w_D - \bar{P}\bar{C}, \\
&(b)\quad \phi_x x N_{-1} + \phi_y Y = w_K K_{-1} + w_L L_L + w_H(H_{-1}uL_H - h_R), \\
&(c)\quad GDP = T_{\tau_B} + [\pi N_{-1} - w_H h_R + w_K K_{-1}] + w_L L_L + w_H H_{-1} u L_H, \\
&(d)\quad GDP = TB + \bar{P}(\bar{C} + \bar{\psi}) = p_x x N_{-1} + P_Y Y + T_{\tau_B}, \\
&(e)\quad TB^i = GDP^i - \bar{P}^i\bar{D}^i = P_Y(Y^i - D_Y^i) + N_{-1}^i p_x^i(x^i - D_x^{ii}) - N_{-1}^j p_x^j D_x^{ij}.
\end{aligned} \tag{B.6}$$

According to (a), household sector savings is channeled into financing the current account, domestic capital investments and newly-issued equity wealth from business formation. Since rental rates of capital are equalized across sectors in the long run and since capital is a homogeneous good, we simply write $w_K K_{-1} = w_K(K_{x,-1} + K_{y,-1})$ for the sum of rental payments of both sectors. Equation (b) gives the composition of value added income at factor cost. By way of contrast, GDP at market prices also includes monopoly profits and indirect taxes as in (c). On the demand side, the trade balance and domestic absorption must add up to GDP which is also equal to the sectoral outputs valued at producer prices plus indirect tax payments [see (d)]. Finally, the trade balance in (e) may be either viewed as the difference between GDP and absorption or as the excess sum of exports over imports.

C Demand

Relying on the above identities, we now use data on GDP, the aggregate trade balance, plus exports and imports of differentiated high-tech goods (see table 2) to calibrate the demand structure as follows. We start with cost normalizations $\phi^i_{x,0} = 1 = \phi^i_y$. Notice that the first of these equalities holds for the benchmark equilibrium only, while the second holds at all times due to our choice of numéraire. The traditional good is priced at unit cost, $P_Y = 1$, while the price of the differentiated good reflects markup pricing, $p^i_{x,0} = \beta$. The markup factor is specified exogenously to reflect average results from econometric industry studies. The tariff rates chosen for differentiated goods, τ^{ij}_B, similarly reflect average values as reported in the literature. We fix units by setting an arbitrary value for $\bar{N}_{-1,0}$.

Given benchmark data for overall domestic absorption $GDP_0 - TB_0$ of each region, we now determine the share s^1_N of domestically produced varieties and the budget share α_{cx} for differentiated goods in total spending, such that the implied demand structure reproduces export and import data in the innovative sector, $EXP_{x,0}$ and $IMP_{x,0}$. The procedure is iterative and based on the following sequence of computations. First, we set $s^2_N = 1 - s^1_N$ and $N^i_{-1,0} = s^i_N \bar{N}_{-1,0}$. Utilizing the above price normalization and the tariff barriers, one may then compute price indices $P^i_{X,0}$ from (10) and the top level Cobb Douglas price indices $\bar{P}^i_0$, using a guess for the expenditure share α_{cx}. This allows to determine the *quantity* of absorption as $\bar{D}^i_0 = (GDP^i_0 - TB^i_0)/\bar{P}^i_0$. The quantities of the standard and differentiated goods used in each region, $D^i_{Y,0}$, $D^i_{X,0}$ and $D^{ij}_{x,0}$, are then readily available from the demand functions. These quantities, in turn, imply benchmark tariff revenues $T^i_{\tau_B,0}$. Market clearing determines output of a representative firm in the high-tech sector, $x^i_0 = \sum_j D^{ji}_{x,0}$. Going back to GDP data, we obtain production levels in the traditional sectors as $Y^i_0 = (GDP^i_0 - T^i_{\tau_B,0} - N^i_{-1,0} p^i_{x,0} x^i)/P_Y$. Moreover, the difference between domestic production and domestic use of differentiated goods implies a unique structure of intra-industry trade in the differentiated goods sector: $N^1_{-1,0} p^1_{x,0}(x^1 - D^{11}_{x,0}) = EXP^1_{x,0}$ and $N^2_{-1,0} p^2_{x,0} D^{12}_{x,0} = IMP^1_{x,0}$, and analogously for region 2. We now iterate on s^1_N and α_{cx} until these equalities hold to a specified level of accuracy. The whole procedure boils down to finding the zeros of a two dimensional non-linear function.

D Production

Since all factors except unskilled labour are in endogenous supply, calibration of production needs to take into account factor accumulation and must be carried out jointly with calibration of growth rates. Two crucial figures which have to be specified exogenously are the real interest rate and the rate of real income growth. Barring any more reliable information, we choose a real interest rate of 4 % to reflect an average over the last two decades. Similarly, judging from past experience of West European countries, we specify the growth rate $\hat{w}$ of wages to be 1.2 %. Notice that in our framework this wage growth is in terms of the standardized good, while in terms of the overall commodity bundle wage growth is higher according to $\hat{w}/\hat{\bar{P}}$ ($\hat{\bar{P}} < 1$). Our model identifies product innovation as the only source of long run wage growth, and our choice of $\hat{w}$ ultimately also pins down the benchmark rate of innovation according to $\hat{w} = \hat{N}^{-(1-\beta)\alpha_{cx}\alpha_{ky}/A}$, where $A \stackrel{\text{def}}{=} \alpha_{cx}(\alpha_{ky} - \alpha_{kx}) + (1 - \alpha_{ky} > 1$ and the various parameters have yet to be calibrated.

In the following we now omit country indices whenever possible without creating confusion. We first note that both sectors use the same type of capital good which is available at a price $\bar{P}_0$. We know from above that both capital stocks grow at a common rate $\hat{K} = \hat{w}/\hat{\bar{P}}$. Noting that $\hat{\bar{P}} = \hat{w}^{-(1-\alpha_{ky})/\alpha_{ky}}$, we take a guess for α_{ky} and calculate the associated $\hat{\bar{P}}$ from our specified value for $\hat{w}$. Denote this by $\hat{\bar{P}}(\alpha_{ky})$ and the associated growth of the capital stock as $\hat{K}(\alpha_{ky})$. Assuming identical rates of decay for both capital stocks, the steady-state investment ratio is $i = \hat{w}/\hat{\bar{P}}(\alpha_{ky}) - \delta_K$. Denote this by $i(\alpha_{ky})$ to indicate dependence on the initial guess for α_{ky}. Turning to the Euler equation, we may write

$$\begin{aligned}
\Big(\frac{r}{\hat{\bar{P}}} - \hat{K}\Big) qK_{-1} &= w_K K_{-1} - \bar{P}\psi(i)K_{-1} \\
\Big(\frac{r}{\hat{\bar{P}}} - \hat{K}\Big) \frac{\psi(i)\bar{P}K_{-1}\psi'(i)}{\psi(i)} &= w_K K_{-1} - \alpha_I \bar{P}\bar{D} \\
\Big(\frac{r}{\hat{\bar{P}}} - \hat{K}\Big) \frac{\psi'(i)}{\psi(i)}\alpha_I &= \frac{w_K K_{-1}}{\bar{P}\bar{D}} - \alpha_I
\end{aligned} \tag{D.7}$$

We may write $(w_K K_{-1})/(\bar{P}\bar{D}) = \alpha_K g$ where g is the ratio of GDP to absorption: $g = \text{GDP}/\bar{P}\bar{D}$ and α_K is the share of capital income in GDP. Since g is already known from above, all we need to complete calibration of α_{ky} is a benchmark observation on α_K.[17] We may then write

$$\Big(\frac{r}{\hat{\bar{P}}(\alpha_{ky})} - \hat{K}(\alpha_{ky})\Big) \frac{\psi'[i(\alpha_{ky})]}{\psi[i(\alpha_{ky})]}\alpha_{I,0} = g_0\alpha_{K,0} - \alpha_{I,0} \tag{D.8}$$

and iterate on α_{ky} until this equation is satisfied.

Benchmark investment expenditure may be written as $\bar{P}_0\psi[i(\alpha_{ky})]K_{-1,0}$. Having calibrated total absorption $\bar{P}_0\bar{D}_0$ above, we may now equate

$$\bar{P}_0\psi(i_0)K_{-1,0} = \alpha_{I,0}\bar{P}_0\bar{D}_0, \tag{D.9}$$

where $\alpha_{I,0}$ is the observed benchmark ratio of investment expenditure to domestic absorption and i_0 is the ratio of investment to capital stock as obtained with the calibrated value of α_{ky} (see above). We solve for the aggregate benchmark capital stock:

$$K_{-1,0} = \frac{\alpha_{I,0}\bar{D}_0}{\psi(i_0)\bar{P}_0}. \qquad (\text{D.10})$$

From the first order condition on investment we now calculate

$$q_0 = \psi'(i_0)\bar{P}_0, \qquad (\text{D.11})$$

and we note that $\hat{q} = \hat{\bar{P}}$. Returning to the steady-state version of the Euler equation for investment, we write

$$\begin{aligned} \frac{r}{\hat{q}} &= \frac{w_K}{q} - \frac{\psi(i)\bar{P}}{q} + \frac{i\psi'(i)\bar{P}}{q} + \delta_K \\ q\frac{r}{\hat{\bar{P}}} &= w_K - \psi(i)\bar{P} + \hat{K}, \end{aligned} \qquad (\text{D.12})$$

where $\bar{P}/q$ was replaced by $1/\psi'(i)$ from the first order condition amd i was replaced from the equation of motion for the capital stock. We may now use this last equation to solve for the benchmark value of the capital rental:

$$w_{K,0} = \Big(\frac{r}{\hat{\bar{P}}} - \hat{K}\Big)q_0 + \bar{P}_0\psi(i_0), \qquad (\text{D.13})$$

where $\hat{\bar{P}}$ and $\hat{K}$ follow from the above procedure to calibrate α_{ky}. Given the functional form of $\psi(\cdot)$ and $\hat{K} = i + \delta_K$ this may equivalently be written as

$$w_{K,0} = \Big(\frac{r}{\hat{\bar{P}}} - \delta_K\Big) - \phi_0(i_0)^2. \qquad (\text{D.14})$$

Knowledge of $w_{K,0}$ now allows to calibrate the capital share of the differentiated goods sector:

$$\alpha_{kx} = \frac{w_{K,0}K_{-1,0} - \alpha_{ky}P_Y Y_0}{\phi_{x,0}x_0 N_{-1,0}}. \qquad (\text{D.15})$$

All of this is carried out separately for each of the two regions, but we note that all *alpha*-parameters are equal in both regions. Moreover, $\alpha_{ly} = 1-\alpha_{ky}$ and $\alpha_{hx} = 1-\alpha_{kx}$. We are now in the position to calculate the rate of innovation as

$$\hat{N} = \hat{w}^{A/[-(1-\beta)\alpha_{cx}\alpha_{ky}]}. \qquad (\text{D.16})$$

E Labour Supply and Education

We specify a value for the intertemporal elasticity of substitution γ as suggested by available econometric studies and invoke the Euler equation to calibrate the rate of time preference as $\rho = r\hat{w}^{-1/\gamma}\hat{\bar{P}}^{(1-\gamma)/\gamma}$ identically for both regions. Having specified $g(\cdot)$ such that its steady-state value is $1 - \delta_H$, we may now specify δ_H and τ_E to calibrate the steady-state levels of educational effort u_0^i and the steady-state level of human capital $H_{-1,0}^i$. These are the same in both regions provided the educational subsidy and depreciation are the same. We then observe the size of the low-skill labour force in both regions to calculate the wage rate $w_L^i = \alpha_{ly}^i P_Y Y_{i,0} / L_{L,0}^i$ that is consistent with wage payments of the traditional sector. The next task is to calibrate the size of the work force with variable skills. To do so, we take a guess value for the wage spread s^i which determines the high-skill wage rate as

$$w_{H,0}^i(s^i) = s^i w_{L,0}^i / H_{-1,0}^i, \tag{E.17}$$

where we explicitly indicate that this wage rate depends on our guess of s^i. From the above procedure we already know monopoly profits $\pi_0^i = (\beta - 1)\phi_{x,0}^i x_0^i$. We invoke the free entry condition for R&D and the no-arbitrage condition to calibrate the productivity parameter:

$$\begin{aligned} v^i &= \pi^i \Big/ \left(\frac{r}{\hat{v}} - 1\right) \\ v^i &= (1 - \tau_R^i) w_H^i a^i \Big/ \bar{N}_{-1} \\ a^i(s^i) &= \frac{\pi_0^i \bar{N}_{-1,0}}{(r\hat{w}/\hat{N} - 1)(1 - \tau_R^i) w_{H,0}^i(s^i)}, \end{aligned} \tag{E.18}$$

where the last equation uses $\hat{v} = \hat{w}/\hat{N}$ and indicates that the calibrated value of a^i depends on our guess for the the wage spread. Note that $\hat{N}$ is known from above. Given the benchmark number of varieties $N_{-1,0}^i$ the number of new products created in the benchmark period is $I_{N,0}^i = (\hat{N} - 1)N_{-1,0}^i$ and the skilled labour requirement is therefore

$$h_{R,0}^i(s^i) = a^i(s^i) I_{N,0}^i / \bar{N}_{-1,0}. \tag{E.19}$$

Multiplying the full employment condition for human capital by w_H, and remembering that $w_H h_x = \alpha_{hx}\phi_x$ we may write this as

$$L_H^i = \frac{w_{H,0}^i(s^i) h_{R,0}^i(s^i) + \alpha_{hx}\phi_{x,0}^i x_0^i N_{-1,0}^i}{w_{H,0}^i(s^i) u_0^i H_{-1,0}^i}. \tag{E.20}$$

We observe the size of the skilled labour force in either region, insert this on the l.h.s. and iterate on s^i until the above equation is satisfied.

A few final steps complete the calibration exercise. Knowing all factor prices, we evaluate the unit cost functions, and enforce the normalizations $\phi_x^i = \phi_y^i = 1$ by appropriately fixing the scaling coefficients $\phi_{0,x}^i$ and $\phi_{0,y}^i$. The government budget constraint yields lump-sum taxes or transfers T_0^i. The value of net foreign assets follows from current account balance and is tied to the trade balance by $B_{-1,0}^i = TB_0^i/(\hat{w} - r)$. Equity values and net foreign add to household sector financial wealth, A_0^i. With all budget identities holding exactly, the value for consumption implied by the savings equation must reproduce the value given in the data set.

F Data Sources

1. The **Western European countries** are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

2. The **Central and East European Countries** (CEECs) are: Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovak Republic, and Slovenia. All data for these countries are taken from the Vienna Institute for Comparative Economic Studies, Hanndbook of Statistics, Countries in Transition 1995. The most comprehensive coverage is for 1993. The 1992 data for the West have been appropriately scaled up to maintain consistency. Since our hypothetical benchmark assumes the counterfactual case of favourable initial conditions we scale up the Eastern labour force by 20 percent to take account of presently unemployed labour.

3. 1992 GDP as well as absorption data for Western European Countries are from: UN (1994), National Accounts Statistics: Main Aggregates and Detailed Tables, Part I and Part II. These are given in national currencies and we convert them into Mio US Dollar using nominal exchange rates as reported in the OECD Economic Outlook.

4. 1992 capital income shares for these countries are similarly taken from the OECD (1994), Economic Outlook, and we take a GDP-weighted average of the above mentioned economies for our hypothetical benchmark equilibrium.

5. The labour force breakdown is taken from various issues of the International Labour Office, Yearbook of Labour Statistics. Occupational categories 0/1 through 5 are identified as high-skill, while categories 6 through X are identified as low-skill labour.

6. Finally, trade data for Western countries have been taken from the UN 'Global Trade Matrix' in machine-readable form.

For the whole set of parameters chosen and/or calibrated, see table A.1, and for the underlying data set, see table A.2.

Table A.1: Basic Parameters

		EAST	WEST
	Taste and Technology Parameters		
r	world interest factor	1.040	
ρ	subj. discount factor *)	1.010	
γ_c	intertemp. el. of subst.	0.700	
α_{cx}	share of x consumption *)	0.676	
β	markup factor	1.400	
σ_H	elasticity education	0.300	
δ_H	depreciation factor skills	0.960	
δ_K	depreciation factor capital	0.900	
ψ_0	adjustment cost param.	10.000	
α_{ky}	capital share y sector *)	0.298	
α_{kx}	capital share x sector *)	0.380	
L_L	low-skilled labour force	15.917	64.652
$\frac{w_H H_{-1}}{w_L}$	wage spread *)	1.344	2.091
u	fraction of time at work *)	0.628	0.628
H_{-1}	skill level *)	9.288	9.288
L_H	high-skilled labour force	26.645	108.224
a	productivity R&D *)	2450.118	2633.111
s_N	share of product range x *)	0.209	0.791
$\bar{N}_{-1}$	world-wide product range	10.000	
	Growth Factors		
$\hat{w}$	wages and income components	1.012	
$\hat{N}$	innovation rate *)	1.100	
$\hat{x}$	output high-tech goods *)	0.923	
$\hat{p}_x$	price high-tech good *)	0.997	
$\hat{D}_{\bar{X}}$	high-tech composite *)	1.055	
$\hat{P}_{\bar{X}}$	PI high-tech goods *)	0.959	
$\hat{\bar{C}}$	total consumption composite *)	1.041	
$\hat{\bar{P}}$	total consumer price index *)	0.972	

Empty second column: same parameter for both regions.

A *) indicates a calibrated parameter.

Table A.2: Macroeconomic Identities

		EAST	WEST
Trade Balance and Absorption			
trade balance Y	+	7.641	-7.641
exports X	+	45.847	53.489
imports X	+	-53.489	-45.847
trade balance	=	0.000	0.000
consumption	+	78.704	255.607
investment	+	21.296	68.345
GDP	=	100.000	323.952
Demand Structure *)			
dem.f.country 1 goods	+	14.153	45.847
dem.f.country 2 goods	+	53.489	173.278
demand for goods X	=	67.641	219.125
demand for goods Y	+	32.359	104.827
absorption	=	100.000	323.952
Output Structure *)			
output Y	+	40.000	97.186
output X	+	60.000	226.767
indirect taxes	+	0.000	0.000
GDP	=	100.000	323.952
Cost Structure *)			
depreciation		12.552	40.283
accounting profits	+	19.631	65.274
capital income NA	=	32.183	105.557
rental capital income		28.196	90.488
monopoly profits	+	17.143	64.790
R&D costs	-	13.156	49.722
capital income NA	=	32.183	105.557
low-skilled wages	+	28.089	68.247
high-skilled wages	+	39.728	150.149
indirect taxes	+	0.000	0.000
GDP	=	100.000	323.952

A *) indicates calibrated values.

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