

# **Vision and Practice of Universities in a Global Context**

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## ***Introduction***

For centuries higher education was usually seen as a kind of luxury good. Only after the industrial revolution in the late 18<sup>th</sup> century the full impact, which this highest strata of knowledge production can have on social welfare started to be understood. Things have changed dramatically since that time. After the heavy downturn of the world economy in 2008 in most countries hopes for recovery were closely linked to a renaissance of innovative activity. And since the latter needs as an essential ingredient new advanced knowledge, it is not surprising that higher education started to rank high in the policy toolset of despaired policy-makers. But initiating changes in higher education proved to be extremely difficult; at least this is the European experience. Academics working in universities command a high level of specialized human capital that not only resists a devaluation of salaries, which anyway lag behind salaries for comparable expertise in the private sector, but this human capital also resist any depreciation of the content of its knowledge. Not to speak of the inability of academic outsiders to provide consistent alternatives to the usual work process of the homo academicus. But change is inevitable if a fall in welfare is to be avoided, at least for Europe this has become the mainstream hypothesis in the last two years.

This paper therefore starts with a fresh perspective on the welfare of a population. Then it proceeds to the idea that cooperation and conflict are the two contradictory elements that enable us to construct a more adequate model of the dynamic interactions in a

social setting with a rich structure – like the world economy. With this first flavor of the need for complex modeling we explain why incentive compatibility is a necessary condition for successful implementation of improvements, in particular for improvements in higher education. But improvements need goal orientation, need a vision of the future global landscape of universities. Chapter 2 is sketching such a vision, heavily drawing on the intricacy of the concept of diversity. Referring back to the need for practical advice for future university design we formulate some practice-oriented ideas. The third chapter then even goes one step further with respect to implementation, and presents a sketch of the simulation tool we constructed to support change in a single university. This heterogeneous agent-based simulation of groups interacting in a university is embedded in a macroeconomic model trying to trace the role of universities in society – with the ability of a tentative quantitative description of the most important relationships.

Despite an enormous amount of published articles for the area of higher education, the number of papers approaching the problems from a similar perspective as this paper does is very limited. Research in this vein is still in its infancy, despite the overwhelming possibilities provided by simulation tools and available data. It remains to hope that many of the cautious ideas we present will be substantiated by future research.

### ***1 – Global welfare enhancement and incentive compatibility***

The point of departure for any consideration of global university policy certainly is the notion of welfare. It is welfare of the population which economic policy aims to increase, and the connotation of the concept already signals that it refers to a measure of a larger group of human individuals. This measure clearly is not easy to define. As microeconomic theorists always emphasize the (cardinal) utility scale of a certain physical individual of the human species (even if it could be unambiguously measured as a time series) cannot be compared to the same scale of another physical individual, computing welfare as the sum total of individual utilities is not a feasible proposal. The

recent decades have seen a lively discussion of the underlying methodological questions in political economy circles<sup>1</sup>.

The challenging contradiction embedded in the idea of global welfare is that seen from one side *cooperation* between two groups in society is defined as enhancing the welfare of both groups, whereas seen from the other side *conflict* between two groups can lead to a global welfare increase or decrease – depending on the relative size of the welfare increase of the ‘exploiting’ group as compared to the welfare decrease of the ‘exploited’ group. This shifts the problem of welfare measurement one level downwards, to the groups constituting the global society. In political terms it reads as the question of weighing the importance of the respective welfare of social groups<sup>2</sup>, it manifests itself for example as the choice of a certain incomes policy. As can be seen easily this shifting is self-similar, it happens on ever smaller sets of a group with sub-groups right down to the level of the physical individual.

The first additional difficulty with this description of cooperation and conflict comes with the observation that in reality no pure forms ever occur. The welfare enhancing division of labor via cooperation appears and coexists always with some kind of welfare decrease for some other group(s) within society. In other words, a certain level of conflict can never be avoided.

Moreover – and this is a second additional difficulty - social processes are a dynamic procedure. What occurs as an exploitative relationship for a short period might turn out to be welfare enhancing for all concerned sub-groups in the long-run. And vice versa<sup>3</sup>! From a theoretical point of view it thus needs *a rather careful dynamic analysis to disentangle net welfare effects for well-defined future time periods*. It is clear that such an analysis cannot be expected to be carried out by an isolated physical individual; it needs specialized higher-level research groups. And this leads us to our core topic, higher education.

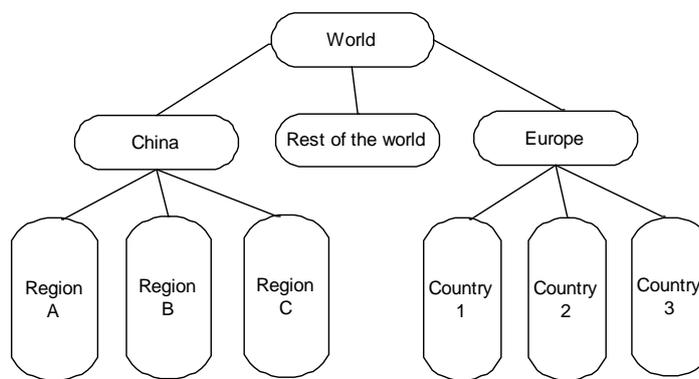
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<sup>1</sup> In economic theory this question usually has been restated as the problem of ‘justice’: how can social institutions devise rules, which are *considered* as ‘fair and just’ by groups within a society. Starting with John Rawl’s fundamental exposition of the so-called ‘liberal’ position [Rawls, 1971], and leading to several layers of critique of this position, like [Roemer, 1996] and more recently [Sen, 2009] these debates have not yet lead to any consensus. But their immediate political relevance cannot be doubted.

<sup>2</sup> Classical political economists of the 19<sup>th</sup> century have called the groups at this level ‘social classes’.

<sup>3</sup> The first direction evidently is the background of the appraisal of entrepreneurial (exploitative) activity à la Schumpeter [Schumpeter, 1911]. The reversed conclusion is particularly relevant for times of deep global crisis: If a short-run optimizing paradigm is followed by many sub-groups in a seemingly cooperative manner, these might prolonger and worsen long-run social and environmental deficiencies, which currently are less visible.

Consider the two geographical and political units of the Europe and China as parts of the global society. Each of these two parts is further structured along certain dimensions. One straight-forward division of Europe would work along European nation states and their corresponding cultural features, and a similar structure certainly could be found for China's regions. Discussing welfare along the nodes of such a hierarchical tree (compare fig. 1) is an interesting exercise.



**Figure 1: Welfare hierarchy**

Though Europe's and China's welfare are both elements of global welfare the latter might be increased either by a simultaneous increase in both (cooperation) or by an increase in one of them, which is stronger than the decrease in the other (conflict). In the former case a coalition of Europe and China (cooperation) could still be conflicting with the rest of the world, or it could strive for what in game theory is called a 'grand coalition' (global cooperation). Again similar arguments apply to lower levels of the tree diagram.

Since standard optimization methods, as often applied in operations research and mainstream economics, take the structure of the information problem to be characterized by full information at all levels, the optimal solution is evident: A benevolent dictator at the top chooses the actions to be chosen at the next lower level to achieve optimal welfare increase, and this procedure is carried on down to the leaves of the decision tree – the single individuals. Optimal welfare increase for all at a minimum of necessity of choice at lower levels would be guaranteed.

But in a world characterized by knowledge accumulation rather than by the existence of an omniscient top agent, this just mentioned trivial special case is of no importance. If needs and utilities of social groups evolve along dynamically changing dimensions, then there is the need also to acquire information that moves upward in the tree of hierarchy. Nodes at all levels have to be designed as feedback loops, which manage to organize the emergence of possible future welfare trajectories. Visions of such trajectories being presented by higher level nodes to lower levels for critical adjustment and replacement; leading to steadily improving – always preliminary - practical decisions. This indeed is the content of what has been called accumulation of knowledge<sup>4</sup>.

At this point of the discussion it is important to recall that the division into regions of China and countries of Europe is not the only possibility. Within each of these two continental societies there also exists a division along the respective levels of education. Though this dimension is slightly correlated to the former one it nevertheless reveals additional aspects.

First education incorporates *elements of local culture* – the inherited characteristic of a singular node, e.g. French education - as well as *elements that are shared by all nodes* of the same hierarchy level – e.g. Chinese culture encountered in all Chinese regions, or structural science (mathematics) found in all global education nodes.

Second education is very time consuming expert activity, which in all sufficiently developed societies has lead to focal points of the education process: *universities in large cities*<sup>5</sup>. The concentration of intellectual powers at certain locations from its very beginnings incorporated two types of activities: *research*, i.e. producing new knowledge, and *teaching*, i.e. the transfer of existing knowledge to younger, aspiring researchers. A side effect of the rise of knowledge in important cities is the liaison between the politically leading elite and the masters of knowledge in universities. In Europe it was only in the wake of merchant capitalism in the 16<sup>th</sup> century that science –

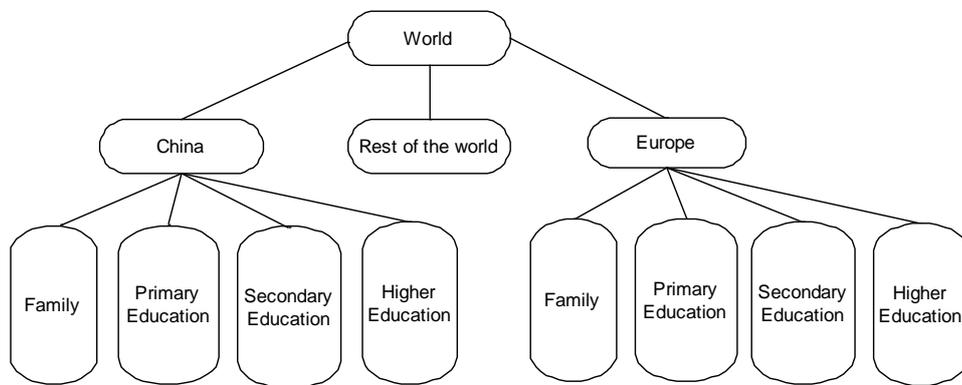
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<sup>4</sup> Accumulation comprises not just newly added pieces of knowledge but also discarding obsolete knowledge and discovery of new avenues of possible knowledge. The more emphatic interpretation of the theory of competitive market mechanisms as well as the political theories of radical democracy as visions typically refer to the upward links in the tree of hierarchy.

<sup>5</sup> For Europe the library of Alexandria in ancient Egypt has been the first university. Note that it emerged in the most powerful empire of this time, which was able to develop the most advanced internal division of labor.

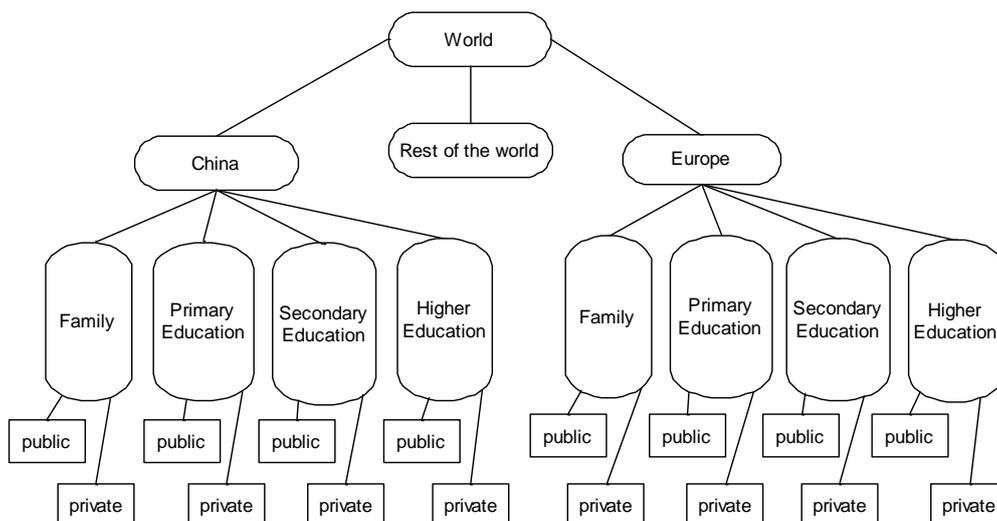
first natural science - slowly started to get rid of its religious fetters, which feudal rulers had always used to cement their ideological power, and had established as an integral part of their universities.

All these particular features of the education scaling of a node like Europe or China still exist today. They directly influence what is considered as welfare, or welfare increase, and thus have to be considered in the design of education institutions. Figure 2 depicts the new perspective.



**Figure 2: Educational divide**

As the diagram makes clear, the big difference to figure 1 is that the elements of education build on each other. Their time dimension, i.e. their duration, counts since they not only designate static (momentary) properties of social groups, but also time consuming teaching and learning procedures that determine long-run welfare in almost every aspect. This is the reason why the design of education institutions is of utmost importance. The long duration of education processes leads to a third possible type of division that recently has been extensively discussed: private versus public education institutions (compare figure 3).



**Figure 3: Public versus private education**

Evidently the education sequence noted in figure 2 has consequences for the interpretation of figure 3. If this sequence is designed using an overarching – in the long-run welfare enhancing - education design, then the partial interference of independent private education enterprises has to be made compatible by appropriate interfaces (e.g. entry examinations of public schools) to the public plan.

The contradiction between short-run profitability necessities of private education institutions on the one hand, and the long-run goal of welfare increase of large political entities nevertheless sets tight limits to the usefulness of private education. People with academic degree are not an ordinary output commodity of a surrogate capitalist firm called university. They cannot be sold, their production period is much too long for any feasible business plan, and in case of failure a fast growing stock of unsold inventory, i.e. unemployed, can cause political unrest, which in turn endangers the overall political climate necessary for capitalist firms. In short, full privatization of education institutions is doomed to fail.

Summing up the diverse arguments, a rather complicated design problem for higher education becomes visible: For some parts of knowledge production (e.g. structural sciences like mathematics, natural sciences, and engineering; call it MNE) the global level seems to be a more adequate terrain. In these areas stronger interaction with

relevant communication between all nodes around the globe would be welfare enhancing. In other areas - like the social sciences, history, and cultural sciences; call it SHC – local knowledge is of much more importance for welfare enhancement. These sciences interact primarily with the mental models their local communities maintain, their merits therefore are directly translated into local mental welfare gain. Depending on this very raw split of sciences the idea of diversity assumes different forms. In case MNE scholars interacting more densely with their colleagues abroad share the same object of investigation – e.g. a formalism, an engineering device – and their diversity only concerns their personal history in tackling the goal. It is the group of scientific personalities which constitutes diversity. In the case of SHC already the objects of investigation are diverse, and as they influence the formation of local SHC scientists, diversity is of a much deeper kind. This might result in an even more creative result of enhanced interaction - if only a common language and enough time for interaction are provided. Why diversity itself is such an important source of welfare enhancement (not only via higher education) should have become clear by now: without a continuous flow of new possible utility dimensions, which are discovered within a set of unforeseen diverse events, welfare is reduced to the dimension of biological survival and growth – it only allows for the survival of the fittest. A closer treatment of the important notion of diversity in the context of university design is sketched in the next chapter.

Before discussing the vision of creative diversity in higher education some remarks on implementation are necessary – how do we get from the current state of affairs to an improvement. From an economic point of view ‘incentive compatibility’ of relevant agents is the magic concept. In a hierarchy without feedback loops (as briefly sketched above) incentive compatibility is completely redundant – all commands come from the top, which already has taken care of all wishes. If the top tells all subjects that this is the best of all possible worlds, and they believe it, then the question of incentive compatibility does not exist. Stupid as it might look at first glance strong hierarchy can be the best solution to welfare enhancement in special situations with very tight time constraints. These typically can occur in a military context, when no time for the shortest feedback loop is available and the success depends on the lonely decision of a

hopefully superior commander<sup>6</sup>. But as education typically is a social process that takes a very long time, full-fledged hierarchy is completely out of question, and the design of incentive compatibility moves to the center stage. So once we are clear where we want to move to (chapter 2), we will have to investigate possibilities to get there by discussing incentive compatibility with the help of simulations (chapter 3).

## ***2 – Fruits and Dangers of global diversity***

Diversity has become a buzzword used in many disciplines. It has gained this status because it indeed circumscribes a blind spot found in all those paradigms used in life sciences and social sciences that subscribed to an analytical apparatus adopted from 19<sup>th</sup> century's physics. This apparatus only allowed investigating general equilibrium and the corresponding (hopefully unique and stable) optimum. There was no room for the empirically observed diversity of living forms. With the 20<sup>th</sup> century formalisms of the natural sciences underwent a dramatic change, which has not come to an end yet. The notoriously slow adaptors in the social sciences in the moment do not even know what to mimic next. As a consequence diversity will remain a vague concept for some more time.

But from an evolutionary point of view vagueness is not always a misfortune, a misleading clear-cut concept can be even worse. With respect to the diversity of higher education it might well be an advantage to keep scientific disciplines offered at the PhD level in a state of permanent emergency, highest feasible flexibility of content and method. To afford such an eclectic design the fundamentals with respect to received formalisms and broad general education of the students reaching that level must be extraordinary profound. So diversity in these highest educational strata on the one hand enters as diversity of content and method. On the other hand the group of students itself should contribute their diverse profiles and cultural backgrounds, and above all their explicit motivations to some more or less centralized locations of common research.

But why should diversity be more than an ingredient of an adequate description of empirically observed phenomena, why should it enhance welfare? The answer of

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<sup>6</sup> A somewhat less coercive field for situations with useful strong hierarchy are team sports.

economic theory at least goes back to Adam Smith, who praised the division of labor into diverse specialized activities as the major source of the wealth of a nation [Smith, 1776]. Only with a range of different special skills spread over the working population, indeed taught to them with a diversity of training measures, only with this precondition the economic symbol of the entrepreneur organizing diversity makes sense<sup>7</sup>.

Diversity has also played a major role in mainstream microeconomic theory. The assumption of convex indifference curves – implying that a combination of diverse consumption always yields a higher utility than consumption of only one of them (bought with the same amount of money) – ensures the uniqueness of general equilibrium results. And in doing so it assumes that there must be an innate preference for mixtures of diverse commodity bundles. Though this looks like an unnecessary side-effect of a technically necessary condition, it still has something to it – as the use of fashions by market psychologists impressively shows. Diversity over time and space often is unconsciously assumed as preferable. The deeper evolutionary truth behind this kind of behavior is that with a stream of diverse future challenges one is better equipped with a diversity of possible behavioral reactions to choose from<sup>8</sup>.

With respect to a vision of better university design several analogies might prove to be useful.

For the whole of higher level education a double strategy has to be followed:

- A strong base of knowledge in undisputed parts of the structural sciences (mathematics, informatics, and the like) has to be provided within each university but with a globally agreed level of proficiency and content. This basic knowledge should be concentrated in the first stage of higher education<sup>9</sup>.
- A high degree of flexibility and diversity should be offered in the second stage of higher education to prepare future academics for the uncertain challenges they might encounter in their professional life. There should be much room for local traditional wisdom and habits of thought as well as for disciplines ranging all

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<sup>7</sup> It is tempting to see a parallel in the emergence of a 'science entrepreneur' created by Japan's MITI or certain US institutions during World War 2. It is remarkable that all such attempts came from political bodies, and not from private investors. The already mentioned long-run perspective is only incentive compatible with an agent representing the common good, welfare.

<sup>8</sup> Even barely fashionable finance departments would subscribe to a diverse portfolio of securities for exactly this reason.

<sup>9</sup> This corresponds to the achievement of literacy in primary education.

across the arts and the sciences. Moreover, student exchange as well as researcher and professor exchange between universities all over the world should be mandatory, since a maximum of diverse encounters should be strived for. The common fundamental skills (stage 1) would provide a fallback solution if language barriers hit – but the establishment of an additional common everyday language would be an enhancement<sup>10</sup>.

- The long-term character of higher education provision implies that universities have to be part of the public infrastructure, which has to guarantee at least the reproduction of society – hopefully with an increase in welfare, but independent of any need for profitability, stock accumulation, financial efficiency or other concepts borrowed from a capitalist firm’s terminology. A university should be a public institution paid by taxes of citizens, and controlled by democratically legitimated public bodies<sup>11</sup>. A university cannot - and never will be - a production firm.
- As a sequel, the global university structure should be commonly developed by the top political institutions of each continent<sup>12</sup>, the institutions responsible for reproduction and welfare growth of their respective society.

As final caveat it has to be remarked that diversity - and its implication to choose some elements out of a diverse set – has a dark side too: Those non-chosen elements are doomed to become extinct. With respect to higher education this implies that there always will be a certain amount of failed academic careers, and political institutions responsible for university design should anticipate what to offer to this group (note again the difference to a capitalist firm’s behavior). Fortunately enough, a world with 100 % higher educated people is not really in reach, a level of 40% in advanced OECD countries (as proclaimed by the EU) would already be an incredible success. It can be this uneven starting point of our world economy, which can be used for a clever design of education distribution. Of course, this implies that employment decisions cannot

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<sup>10</sup> As the historical development has created a path dependency, which only could be reversed at a very high cost, the evident candidate for that role is the English language.

<sup>11</sup> Universities do not sell academics to buyers at markets, so there are no anonymous ‚market forces‘ guiding the decisions of a university. The impact of universities on the future of society has to be mediated directly by the democratic political process, which develops the global society’s long-run goals as they emerge.

<sup>12</sup> This indeed would be an excellent exercise on the way to a common global top institution, a social agency that the UN promised to become but so far has failed to make progress towards.

remain the domain of private capitalist firms, there must be a strong influence from global political institutions supplementing and substituting firm decisions. The currently frightening diversity of living standards across the globe demonstrates vividly that counteraction from political side is needed badly.

Having discussed the vision for higher education, we now take the final step towards practice and present a brief sketch of a simulation tool, constructed to provide some help on the way from the current situation to the implementation of the vision.

### ***3 – From vision to practice: a simulation model for university design***

In the research project U-SIM-7 a prototype simulation of a typical university, which is embedded in a macroeconomic environment, is developed<sup>13</sup>. The goal of U-SIM-7 is to explore the interdependencies between the design of a university, including central quantitative parameters, and the overall economic performance of the national political economy in which it is embedded. This type of investigation should provide new, i.e. less singular and more consistent insight into the possible reform paths of tertiary educational institutions that currently are on the agenda in the member states of the European Union.

The simulation approach implies that the usual macroeconomic perspective on higher education institutions, which only concentrates on overall budget and accounting issues, is enriched by a much more detailed simulation of the incentive structures of the concerned microeconomic agents (students, researchers, teachers, administration, policy makers, and production-units).

Such a simulation of the internal model-building process of the micro-agents (internal models on which they base their actions) enables the study of several important aspects of the education process:

- Dynamic adjustment of expected utility from available actions (e.g. join/continue/leave the university) including strategic behavior (i.e. game

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<sup>13</sup> The name U-SIM-7 refers to ,University **S**imulation 2007', the year when the project started.

theory).

- Communication structures (within the group as well as with external media) which influence internal model-building.
- Personality split into different roles of the same physical individual (e.g. researcher/teacher, researcher/administrator, part-time-student/part-time-employee).
- Introducing a type structure (a vector) for each kind of micro-agent allows for the specification of particular characteristics (e.g. devotion to research, rent-seeking behavior, laziness/effort/talent, income situation, management abilities). The share of each type in the agent population is then a parameter of a simulation run.
- Detailed specification of how the higher education process is embedded in the macroeconomic process, i.e. with which output structure of scientists, academics, drop-outs, retired teachers, laid-off teachers, and so on which macroeconomic effects will follow, and will change the input structure.
- Simulation of the competition between universities with different specifications. In particular exploration of possible strengths, niches, and the scope for cooperation in a given macroeconomic environment (e.g. how many universities of which type are useful for the socioeconomic environment in a country).
- Evaluation of the aspirations of policy agenda like the Lisbon process in the light of above mentioned dynamic incentive structures.

The prototype U-SIM-7 allows for the specification of several heterogeneous sets of micro- agents: students, teachers, researchers, administrators, policy makers. Within each of these sets a further (but rather limited) sub-division into types is allowed for; e.g. five student types with different financial backgrounds can be distinguished, different types of coinciding teacher-researcher mixes can be assumed, and so on. Each agent type acts according to its own internal model.

The endogenous dynamics of these sets work within a set of exogenous trajectories that characterize economic supplies for a university's inputs (people, financial inputs, ...) as well as economic needs for a university's output (academics, skilled drop-outs, patents,

knowledge, ...). In a simple macroeconomic growth model macroeconomic performance, including welfare implications, serves as exogenously given embedding scenario.

The innovative character of this project is evident: It uses a new methodology - large scale micro-simulation techniques - to address the burning question of education policy, which to our knowledge has not been studied adequately yet.

Most of the studies done in the field either started from questions concerning the microeconomic choice of individuals to invest in their education (but disregard the rich social and institutional framework this choice is embedded in, e.g. [Booth et al, 2007]), or they start with the policy makers problem of how to allocate budgets across universities and disciplines (but disregard the incentive structures of different types of agents as well as the regulatory framework, which channels their actions. e.g. [Johnson & Turner, 2009]). Combing the most essential elements necessary to explain the current shape of universities clearly is not only an innovative task, but also an extremely demanding one.

At this point the second innovative element comes to the theorist's rescue: The rather new method of heterogeneous agent based modeling (ABE) is a simulation technique, which could take care of many problems not amenable to the traditional solution methods of mathematical economics. Though agent based modeling has been applied to a wide range of topics, in particular in the context of models of market mechanisms, there seems to be almost no application with respect to the modeling of higher education institutions. It is used for this project since it allows for a more explicit formalization of institutional rules as well as communication structures between heterogeneous agents using different (boundedly rational) internal models. Clearly this innovation comes with a price: The answers given with such a simulation will not be universal and eternal truths, but will only provide an improved evaluation of the options available at a very specific point in time within a rather specific setting of economic and political forces. The necessity of a rather excessive specification of the current situation can be seen as a curse or as an asset: On the one hand it adds certain arbitrariness to all issues, since it excludes environments specified differently, while on the other hand it generates

particularly important insight for actual policy processes. In any case the prerequisites needed for a state of the art ABE are extremely labor intensive and include a high degree of interdisciplinary abilities. Given these preconditions, the project promises to become a highly appreciated innovative tool for scientists as well as for decision makers in education policy<sup>14</sup>.

In a sense this ongoing project finishes the intellectual journey from grand theory to local practice undertaken in this paper. As education policy itself it will remain work in progress for more years to come.

## ***Conclusion***

China and Europe are on a quite different track with respect to economic development. While China's per capita income still is below that in Europe, the growth of this figure is rapid in China, while it stagnates in Europe. Welfare – if measured with such an insufficient index at all – certainly follows this pattern. The need for higher education in both continents, Europe and Asia, is a pivotal element of future welfare – though different parts of the world certainly to some extent need different types of academics.

This paper has tried to disentangle the many arguments surrounding this question, and has come up with some practice oriented advices. Finally we also showed how even at the local level of a single university simulation tools could look like, which could help to implement a new type of university – how to get from today to tomorrow, or better: from this generation to the next generation.

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<sup>14</sup> In the appendix an excerpt of the general function form of the model is shown, together with a graph showing qualitative relationships. It should provide a flavor of the type of complexity modeling needed.

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## Appendix

### General Function Form of U-SIM-7 (excerpt)

(‘exo’, ‘endog’ means exogenous, endogenous)

Pop ... population – exo, stock  
Pop%imm ... share of immigrants in Pop – exo, share  
Knwimm ... average education level of immigrants – exo, index  
Mat ... number of domestic pupils finishing secondary school – endog, flow  
G2ndedu ... government expenditure for secondary school (real) – exo, flow

$$Mat = Mat(Pop, Pop\%imm, Knwimm, G2ndedu) \quad [1]$$

StuBeg ... number of 1st semester students, national – endogen, flow  
wAca ... average wage of academics (real) – from A10, index  
w ... average wage (real) all employees – from A10, index  
uAca ... unemployment rate academics – from A10, share  
u ... unemployment rate – from A10, share  
StuDur ... average length of study – endog, years  
StuCost ... average tuition fee – exo, flow

(The macroeconomic growth model A10 is based on a 10 x 10 input-output framework with 10 sectors.)

$$StuBeg = StuBeg((wAca - w), (uAca - u), StuDur, StuCost) \quad [2]$$

StuBegTU ... number of 1st semester students, this university – endog, flow  
wAcaT ... average wage of academics from this university – endog from A10, index  
uAcaT ... unemployment rate academics from this university – endog from A10, share  
StuDurT ... average length of study, this university – endog, years  
StuCostT ... average tuition fee, this university – exo, flow  
RepUni ... average reputation of universities, national – exo, index  
RepTU ... average reputation of universities, this university – endog, index

$$StuBegTU = StuBegTU(StuBeg, (wAcaT - wAca), (uAca - uAcaT), (StuDurT - StuDur), (StuCostT - StuCost), (RepTU - RepUni)) \quad [3]$$

The following three functions describe entry into this university. A lagged variable of the left side is used on the rate side with a coefficient describing inertia of adaptation.

DoutTU ... number of dropouts, this university – endog, flow  
StuTU ... number of students, this university – endog, stock  
AbsTU ... number receiving academic degree, this university – endog, flow

$$DoutTU_t = (StuTU_{t-1} + StuBegTU_t - AbsTU_t) - StuTU_t \quad (\text{Definition}) \quad [4]$$

Since the number of dropouts is explained via [4] the decision to continue the study has to be explained by a behavioral equation.

$$StuTU_t = StuTU_t(StuTU_{t-1}, (wAcaT_t - wAca_t), (u_t - uAcaT_t), StuCostT_t) \quad [5]$$

The number of produced academics per year is influenced by the size of this university, the number of students at this university and the average length of study.

$$AbsTU_t = AbsTU_t(StuTU_t, StuDurT_t) \quad [6]$$

The average length of study thus is of central importance. It is influenced from the side of students (their social and financial conditions), from the side of professors (quality of teaching, influence on curricula), and from the side of political institutions (e.g. pressure to shorten study duration).

StuTUsL ... social conditions of students, this university - endog from A10, index

BqTU ... quality of teaching, this university - endog, index

StPl ... average *regular* study duration, this university – endog, years

StPIUL ... influence of teachers on the average *regular* study duration, this university – endog, years

StPIPo ... influence of politics on the average *regular* study duration, this university – exo, years

$$StuDurT_t = StuDurT_t(StuTUsL_t, BqTU_t, StPl_t) \quad [7]$$

$$StPl_t = StPl_t(StPl_{t-1}, StPIUL_t, StPIPo_t) \quad [8]$$

For the quality of teaching the ratio of students per teacher as well as the expenditure (excluding wages of university employees) of the university is an input argument.

BudTUc ... expenditure (excluding wages of university employees) of this university – exo, flow

ULTU ... number of teachers at this university – endog, stock

$$BqTU_t = f^9(BudTUc, \frac{ULTU_t}{StuTU_t}) \quad [9]$$

The influence of BudTUc is modeled with falling weights over the last five years.

### Some qualitative relationships

