2018 ASEE Annual Conference & Exposition
June 24–27, 2018 Salt Palace Convention Center Salt Lake City, UT
Paper ID #23151

Learning from Failures: Engineering Education in an Age of Academic Capitalism

Mr. Andrew Katz, Purdue University, West Lafayette

Andrew Katz is a doctoral candidate in the School of Engineering Education at Purdue University. He holds a B.S. in chemical engineering from Tulane University and M.Eng. in environmental engineering from Texas A&M University. Prior to beginning his graduate studies in engineering education he taught physics at a high school in Dallas, TX.

Dr. Donna M. Riley, Purdue University, West Lafayette

Donna Riley is Kamyar Haghighi Head of the School of Engineering Education and Professor of Engineering Education at Purdue University.

Learning from Failures:
Engineering Education in an Age of Academic Capitalism

Abstract

In recent decades, scholars of higher education have noted the increasing corporatization and marketization of higher education - the trend of universities behaving like businesses and treating higher education like a market good. Although this same general phenomenon is not necessarily new (it was noted by Thorstein Veblen almost one century ago), contemporary trends might suggest an acceleration of this transformation of higher education beginning in the final third of the 20th century. Common examples of this shift include: students increasingly treated like consumers; a growing number of universities run by former business presidents and CEOs; the growth of the for-profit college sector; faculty members encouraged to translate their research into private business ventures; and departments that vie for research funding dollars and publications. Researchers have coined the term "academic capitalism" to characterize some of these phenomena, emphasizing the notion of universities and their constituent components functioning like businesses. Books like *University, Inc.*, *Universities in the Marketplace*, and *The Lost Soul of Higher Education* chronicle this same movement by expounding upon the myriad ways the transformation process has unfolded. In short, the form and function of higher education are changing. Engineering education is not immune to these changes since it is embedded within the structure of higher education; in fact, given its close industry ties, it may be especially vulnerable to these phenomena.

While proponents of a market-based approach in higher education are sometimes loath to discuss it, classical microeconomic theory and good public policy demand a concomitant exploration of market failures. A market can be considered as a mechanism designed to enable transactions of exchange between consenting parties to achieve efficient allocations of goods and resources. Subsequently, market failures may arise when the market does not reach this efficient allocation, or more generally when it fails to promote desirable activities or to stop undesirable activities. Importantly, these market failures can also require different responses to mitigate their effects. Such responses may include tailored policy implementation and institutional arrangements.

Given the treatment of higher education as a market good and the dearth of discussion of potential market failures in this arena, this paper explores the intersection of market failures and higher education through the specific case of engineering education. What potential market failures exist, if we are to treat engineering education as a market good? What policy interventions might therefore be justified to remedy such failures? How might engineering education researchers adopt economic and policy analysis arguments to help frame and characterize current trends and dynamics in the broader engineering education ecosystem? How might administrators and policy-makers ultimately address market failures, or otherwise correct the treatment of engineering education and higher education as market goods? Researchers and policy-makers could benefit from understanding the language of market failures and recognizing their general characteristics when approaching their own work in engineering education because it may help them describe phenomena of interest in engineering education and provide a conceptual framework for analysis and eventual improvement.

Introduction - Higher education and markets

Economic policy changes since the 1970s

The 1970s were a tumultuous decade for American economic policy. Events like the oil crises in 1973 and 1979, the U.S. withdrawal from the Bretton Woods monetary agreement, and stagflation - the combination of low economic growth, high unemployment, and high inflation rates - began to cast doubt upon the incumbent Keynesian economic policy paradigm [1, p. 372], [2, p. 20], [3]. Beginning in this decade, both domestic and international economic policy began to shift away from accepting a role for the government in shaping economic policy and toward a minimized role focused on ensuring proper market functioning and little else. This retraction of government regulation and intervention came under the name of neoliberalism. Neoliberalism is broadly characterized as a combination of neoclassical economic ideology and classical liberalism that emphasized minimal state intervention and a reliance on marketplaces to enable personal liberty [4, p. 33]. The reader should note ambiguities in how one defines liberty in these discussions. At the time, liberty ostensibly adhered to Isaiah Berlin's concept of negative liberty - freedom as defined by the absence of coercion - rather than positive liberty - freedom defined as the presence of capabilities or opportunities [5].

The term neoliberalism antedates the 1970s, first appearing in 1938 [4, p. 30], but the events of the 1970s presented an opening in the Overton window for a paradigm shift; the Keynesian policy levers were proving ineffectual and politicians started looking for alternative maneuvers, thus presenting the space for neoliberal policies to gain traction in the policy arena. In Milton Friedman's own words:

> Only a crisis - actual or perceived - produces real change. When that crisis occurs, the actions that are taken depend on the ideas that are lying around. That, I believe, is our basic function: to develop alternatives to existing policies, to keep them alive and available until the politically impossible becomes the politically inevitable. [6]

Simply put, out with the Keynesian policies and in with the neoliberal policies. Over time, this shift has translated to a deregulatory policy outlook and insistence on markets as the solution to problems that have appeared in public and private life. This market-based logic associated with neoliberalism has extended into the area of higher education and public policy. In effect, the shift has entailed a marketization of higher education by treating it as a market good, applying associated rules and norms, and attempting to minimize the role of government intervention in order to liberalize the higher education sector. Given engineering education's embedding with higher education, the same shift has arguably affected engineering education. The reader should note that we do not intend to use the term "neoliberal" in a pejorative sense nor as shorthand for something inherently insidious for the purposes of the paper; rather, it is a characterization of a general ideology underwriting significant portions of public policy, particularly those that came to prominence during the eras of Reagan in the U.S. and Thatcher in the U.K.

Higher education and marketization

The trend toward marketization of higher education in the United States as a consequence of neoliberal economic ideologies and policies is part of a broader, similar global trend in higher education [7], [8]. Instances of this qualitative shift in higher education appear in numerous areas, including: the trend in treating students as consumers [9]–[11]; public-private partnerships that emphasize monetizing university-related activities [12]; former CEOs occupying university presidency positions [13, p. 13]; the growth of for-profit colleges [14]; and faculty members turning their research into business ventures, enabled by the Bayh-Dole Act of 1980 [15]. While each of these examples individually might not embody the canary in the coal mine, together they do support the hypothesis that a shift is occurring in higher education that treats education like a market good. To be clear, this is not necessarily a new trend - Thorstein Veblen noted the incursion of businessmen into the operations of American higher education in the early 20th century; however, the trend may be accelerating in conjunction with the economic paradigm shift. Indeed, the rise of this market phenomenon spurred Slaughter and Leslie to invent the label of "academic capitalism" [16], [17]. Academic capitalism is a term of art to capture these market-like behaviors within universities as the result of the aforementioned shifts in organizational/institutional attitude and economic policy. Since the current paper is dedicated to thinking through the potential impacts and implications of this shift for engineering education through the lens of market failures, we do not examine the nuances of the term academic capitalism and its accuracy, as has been discussed elsewhere.

With the pushing of higher education into markets comes the prospect of market failures. To begin, loosely speaking, one may consider a market to be a mechanism for organizing interpersonal transactions for exchanging such resources among individuals with discrete interests [18]. In establishing markets (or at least for modeling purposes), one may make several assumptions about a market's operations and the conditions necessary for achieving efficient allocation. Those assumptions revolve around the substitutability of products, many buyers and sellers, no barriers to entry or exit into the market, and perfect information among transacting parties. In theory, these markets enable efficient allocation of resources among buyers and sellers. At the abstract level, efficiency can entail efficiently producing goods with a given set of resources or alternatively it can correspond to efficient allocation/distribution of those goods [19, p. 31]. The reader should note that there is a more elaborate set of frameworks for thinking about equitable distribution of resources, which we discuss in a brief aside in order to highlight the room for flexible interpretation in the ensuing conversation about higher education and market failures.

Frameworks for thinking about efficiency in marketplaces can include the traditional Pareto efficiency typically referenced in academic conversations of economic efficiency, Kaldor-Hicks efficiency, and Rawlsian efficiency. Under a Pareto optimal paradigm, efficient outcomes are those in which no rearrangement of distribution can occur that would improve person A's utility without reducing person B's utility [20]. In other words, nobody can be made better off without making someone else worse off. Under a Kaldor-Hicks paradigm, transactions in which some people have higher utility and others have lower utility are permissible as long as the people with diminished utility as a result of the transaction are compensated appropriately [21]. Finally, a Rawlsian efficiency distribution scheme would support outcomes that improve the position of the worst-off individuals in society [22]. The point here is to more finely elucidate potential interpretations of efficiency since those definitions can affect the meaning of a market failure. As we will reiterate throughout this paper, there is no explicit intent herein to offer a normative assessment; instead, we primarily aim to bring these issues to the attention of the engineering education community and suggest paths forward.

Considering the assumptions about necessary conditions for properly functioning markets above, a failure to satisfy those assumptions can lead to suboptimal outcomes and potentially unintended consequences. Failed assumptions, shortcomings, and unaccounted for conditions can manifest as inefficient allocation of resources, a phenomenon known as a market failure [23]. The standard types of market failures include: non-competitive markets, public goods, externalities, principal-agent problems, and information asymmetries. In theory, any of these types of market failures could arise when markets exist to organize transactions between parties. Therefore, given the increased treatment of higher education as a market good, there could also be market failures in higher education. Furthermore, since undergraduate engineering education is part of the higher education system, it follows that these market failures could affect engineering education. The possibility of this condition warrants further consideration and rectification, if accurate.

Higher education and market failures

Market failures in higher education can be defined as the failure of higher education to produce economically efficient outcomes from an optimized level of investment [24, p. 44]. In practice, this can mean several things depending on how one defines efficiency, which was the justification for reviewing possible interpretations above. Specific examples of market failures in higher education can include: the student loan market where there is asymmetric information between students borrowing money from banks to finance their education and near-monopolistic concentration of market power in the hands of a small number of universities such that they behave like monopolistic incumbents [25, p. xii]; price-fixing among elite institutions [7]; and incomplete information for prospective students to make decisions about their future education choices [26].

For the purposes of this paper, we proceed through the exercise of taking each of the aforementioned types of market failures, envisioning how they might affect engineering education, and beginning to outline how researchers and policy-makers could respond. The reader should note that at this stage of conceptualization we do not intend to limit ourselves to purely financial transactions. If one takes a neoclassical definition of economics as "the science that studies human behavior as a relationship between ends and scarce means which have alternative uses" [27], then those scarce means need not necessarily be pecuniary in nature. Time would be an example of this.

The remainder of the paper addresses each of the five market failures in turn, providing a basic definition, canonical examples, candidate examples in engineering education, and implications for research and policy. The paper concludes with a brief discussion of limitations for this analysis and a closing remarks.

Exploring potential market failures in engineering education

In the introduction, five basic sources of market failures were identified - non-competitive markets, public goods, externalities, information asymmetries, and principal-agent problems. In this section we review each of these five sources in turn, proceeding with a standard definition, examples, and implications for research and policy in engineering education. Some of the examples provided are more concrete than others. For each type of failure, we invite the reader to reflect on their own involvement in engineering education and consider examples from their own experiences in engineering education in order to (a) to personalize the analysis and (b) help demonstrate the potential applicability of this approach.

Public goods

We first take up the notion of public goods, because prior to marketization, education (particularly universal public primary and secondary education) was commonly recognized as a public good [28]. Public goods are goods or services whose consumption is both non-rivalrous and non-excludable. This means two separate things. The first condition means that one person's consumption of that item does not prevent another person from consuming the same thing. The second condition means that nobody can be excluded from consuming that good. Canonical examples of public goods include national security, lighthouses, and fresh air. For example, one ship's use of the light provided by a lighthouse does not prevent another passing ship in the night from also using that lighthouse's light for navigation (i.e., it is non-rivalrous). Similarly, there is no reasonable way to prevent a ship from using that light (i.e., it is non-excludable). In this conversation, it is important to note the distinction between public goods and the public good, as discussed by Marginson [29], where the former relates more to economic production of items (i.e., goods) and the latter relates to a normative conception of collective improvement - something that is good for the public. Semantically, this is the difference between *a* public good and *the* public good.

Knowledge production is a standard example of a public good associated with higher education [30] and therefore engineering education, by virtue of its embedding within higher education. Free online courses and pedagogical content are additional candidates of public goods because they are by definition both non-rivalrous and non-excludable. For example, sample ethics lessons from the National Academy of Engineering's Online Ethics Center (www.onlineethics.org) might constitute a public good because one professor's use of a sample lesson in their class does not prevent another professor's use of that same lesson. Similarly, the materials are publicly available and non-excludable as long as someone has internet access. Open enrollment public universities might also effectively meet these criteria (in relation to the local states and regions they serve at low or no tuition), as long as the cost of attendance is kept sufficiently low so as not to be a barrier to entry, and education is delivered at such a scale that non-rivalry conditions are approximated.

Daviet [31] notes that education has never fit cleanly into strict microeconomic definitions of a public good, even as it is commonly thought of that way. She notes that one *can* exclude students from schooling, and at some point, adding additional students *does* negatively impact the ability of other students to benefit. Yet defenders argue that it is at least a quasi-public good, as compulsory, universal education approximates a public good, far more closely than it does the prototypical private good.

Research questions investigating public goods in engineering education could address the exploratory question of whether there truly are more areas of public goods within engineering education. A separate sample research questions could ask, is it a public good simply to have more citizens educated as engineers? This is related to the notion of a positive externality, discussed in the next section, and the notion that engineering generates improvements for civilization and therefore almost by default is a public good, which relates to Downey's notion of normative holism and techno-optimism [32]. Policy to address public goods in engineering education could rectify hypothetical market failures related to these goods and services by increasing incentives to encourage production of these public goods, e.g., subsidize the producers of the research knowledge (i.e., grants) and pedagogical content (i.e., seed funding). Given the public nature of these potential goods, these policies would most likely heavily rely upon government-level decisions.

Non-competitive markets

Non-competitive markets are those with a small number of producers or consumers of a good or service. This can include both monopoly, the familiar domination of a market by a single producer, or its consumer-side analog monopsony, the domination of a market by a single consumer. Regulation exists in the form of antitrust laws in order to stymie the existence of such markets. Canonical examples of non-competitive markets have traditionally included utilities and telecommunication markets. On the monopsony side, a contemporary example could be Walmart and its ability to dominate wholesale purchasing from suppliers.

Non-competitive markets in engineering education could arise whenever there is one person/organization/institution involved in providing or "consuming" a good or service. On a regional level, this could arise from engineering programs themselves if there is a paucity of programs for students in a certain geographical area, or for a particular technical specialty. In this example, there might be a small number of schools offering an engineering course of study. As a result, students interested in engineering (or a particular type of engineering) would have minimal options, leading to a potentially non-competitive market because the extant program(s) do not have to compete with other engineering programs to enroll engineering students. Barriers to entry for new engineering programs in part due to high capital investments in facilities could further exacerbate this problem of non-competitive markets in a particular region. Accreditation also presents another barrier to entry for new engineering programs into the region.

Potential research into the area of non-competitive markets in engineering education could ask the following questions:

1. How do students think about an absence of competition for where they attend university? Does this affect what they study or which engineering discipline they pursue?
2. How do textbook companies exercise market power in their pricing decisions, and how do potentially high learning resource prices affect student decision-making?

3. Generically, how does a lack of option in X affect Y? (X could be choices for instructor in a particular class, time offerings for a course, company recruiting students from a department (monopsony); Y could be behavior, preferences, learning outcomes.)

In the realm of policy, solutions to the market power problem may be hard to come by – a potential limitation of this general market treatment or a possible signal of its occasional inapplicability. Granting this limitation, it may nevertheless be helpful to imagine corrective policies that could minimize the effect of one person or organization exercising monopoly (or monopsony) power. In the simplified case of a faculty member who is the sole instructor for a particular required course, there could be departmental policies that require continual course improvement effort or internal course reviews by other faculty members, although some may balk at the suggestion of more departmental committees. Candidate policies could help encourage the faculty member to avoid becoming complacent and unresponsive to student requests for different pedagogical approaches, for example, or assigning excessive amounts of homework to the point of diminishing marginal returns such that students spend time, a valuable resource, engaged in potentially minimally useful exercises. In general, one of the goals of these policies would be to prevent one actor from exercising outsized power and coercing other actors to form certain preferences or behave in certain, suboptimal ways. Of course, this begs the question of what defines optimality, which would be left to the policy-makers and other stakeholders to contemplate.

Externalities

Externalities are costs or benefits that accrue to third parties as the result of a transaction where they did not directly choose to participate in the transaction. These externalities can be further classified into positive externalities - where the third party receives benefits as a result of the transaction - and negative externalities - where the third party incurs costs. Common sources of positive externalities could include vaccination and education. On the other hand, negative externalities can arise from air pollution and systemic risk.

Externalities related to engineering education can use the standard positive/negative dichotomy. Positive externalities from engineering education could include the general spillover effects associated with public education such as a more highly educated population [33]. In an economic sense, another positive externality could be the increased technological innovation and economic growth in a society associated with having more engineers [34], [35], which generally improves standards of living in a society. The basic idea here suggests that engineering students would incur the costs (and benefits) of deciding to study engineering, which eventually translates into a country having more engineers. Negative externalities from engineering education might arise from having more university students who are less interested in civic engagement. If it is the case that STEM graduates experience a phenomenon of social disengagement [36] and tend to be less socially engaged than non-STEM graduates [37] then there could be an issue of generating a population consisting of less engaged citizens. This disengaged population then creates costs for society writ large when that society's governmental structure is predicated on democratic participation and representation.

As with other types of market failures, basic research related to externalities could simply work to identify their existence and conditions that facilitate or stifle that existence. For example, if it is a negative externality of engineering education that students in general become less interested in civic engagement as they proceed through their programs then research could identify outlier programs whose students do not adopt that disengaged outlook and characteristics about those programs that help mitigate the deleterious effects. Similar to research that suggests there is a positive externality associated with a country having more engineers, research could investigate whether there is a positive externality associated with a country having more engineering schools, following a similar logic that more engineering schools would correspond to more engineering graduates, which in turn corresponds to more practicing engineers and the observed effect of improved economic growth and innovation. Alternatively, one could attempt to untangle whether there are international positive and negative externalities that extend beyond domestic costs and benefits.

Typical policy solutions in the presence of positive externalities from activity X suggest that there should be more of X, which means policy interventions should help promote more X. For example, if it were the case that having more engineering graduates generated positive externalities then governments could adopt a policy of offering financial aid to engineering students in order to reduce their costs of attendance, thereby potentially leading to more students pursuing engineering due to the reduced price (assuming high elasticity of demand). This is obviously a simplified model of how a policy prescription could increase the number of engineering students, but the point is to introduce policies that alter the cost-benefit analysis that students might engage in order to encourage more students to pursue engineering. Alternatively, in the presence of negative externalities, policies should limit activity X or at least help individuals better evaluate the consequences of that activity. For example, if it is indeed a negative externality of engineering education that more university graduates are socially disengaged then policy prescriptions should introduce ways to reverse that disengagement, possibly by encouraging faculty members to emphasize the relevance of social issues in engineering practice. This might be achieved through mechanisms like accreditation standards that change the expectations of a program's graduates and their social competencies. Such measures would admittedly rely upon self-regulating actions that are typically unobserved in traditional examples of negative externalities – self-imposed constraints are not notably common. On the other hand, external bodies typically do not exercise control over the internal workings of engineering departments, further exacerbating the problem of misalignment – those who might want to introduce change are not positioned to do so and those in the position to introduce change might not want to do so.

Information asymmetries

An information asymmetry arises when one actor in a transaction has more information than the other actor(s). The asymmetric knowledge can then lead to either undervaluing or overvaluing, depending on the nature of that knowledge and the actor's role in the transaction. A standard example of information asymmetry is adverse selection, where a buyer or seller might have more information than the other person in the transaction, such as insurance contracts where the purchaser may know more than the insurance company. A second example of an information asymmetry is insider trading, where either the buyer or seller has inside information about a company and trades securities based on that information. A third example that Kenneth Arrow highlights is education itself, which he claims is “the extreme form of a product about which there is asymmetric information”[38].

Engineering education examples may coincide with typical issues in higher education. A classic example of information asymmetry in higher education is the undervaluing of an undergraduate degree by students and their families because they do not realize the potential net benefits they might receive as the result of their education. This partially arises due to non-market benefits. Private non-market benefits about which students typically do not know, e.g., better health, child health, mortality and longevity rates, improved household management [24, p. 120]. Another example of information asymmetry in engineering education could be if faculty members have information about their department or their graduates that incoming students do not know but the knowledge of which might affect their decisions to study in that department. Specifically, imagine the scenario where a student wants to study engineering and music but the advisor knows that this logistically is not sustainable; yet, despite that information, an advisor under pressure to improve enrollment numbers for funding purposes could encourage the student to try the two anyway. This incomplete information could lead the student to make a decision they might not have otherwise made. A third example of asymmetric information relates to ethical dimensions of engineering work for engineering students to consider. In particular, there is a possibility that students may eventually be in a position where they are the ones with more information, such as the scenario where they know more than a customer or community member, which can affect informed decision-making in a variety of ways [39]. Finally, program graduation and placement rates are another source of information asymmetries. This general phenomenon contributed to the Department of Education initiating and publishing the College Scorecard (https://collegescorecard.ed.gov/) in the name of increased transparency and better informed decision-making for students.

Basic research questions to investigate the effects of information asymmetries could look at varying preferences and behaviors that students exhibit in response to more or less information provided by universities, programs, professors, employers, etc. The research could also look for ways to improve information acquisition among actors within the engineering education community. This would involve the aggregation of pertinent information in accessible locations, its acquisition by interested parties, and subsequent interpretation of the information for decision-making purposes.

Policy could improve transparency in order to reduce these asymmetric information relationships, but as Ken Arrow notes, some asymmetries are bound to remain, as “the process of education consists of changing the knowledge of the student. It is therefore necessarily the case that the university is better informed about the desired outcomes and the ways of reaching them” [38]. Facilitating translation of available information can certainly help students and families make better informed decisions (e.g., the difference between the sticker price of a degree and the actual price after financial aid, which can act as a deterrent for some students who are debt averse). This is one of the fundamental ideas motivating the Department of Education’s College Scorecard previously mentioned. Comparable future efforts at the school and department level would need to identify relevant metrics, data sources, dissemination methods, and education mechanisms to enable the recipients of the information to maximally employ that information, and help students and families think beyond simple returns on investment through salary or credentialing to broader, more holistic, and less tangible benefits. In part, such policies might require transcending a program's own interests in selectively divulging information for public perception purposes, especially if some information portrays the program negatively. Related to the example above where engineers working in a community have more information than community members, policies to make engineering education more accessible to the public through government-funded or philanthropic programs might help address this issue.

Principal-agent problems

Principal-agent problems are defined by the presence of a principal (someone with a specific preference who is not able to take actions to directly achieve that preference) and an agent (someone who the principal enrolls in order to achieve the principal's preferences) [40]. In other words, the agent acts on behalf of the principal. General principal-agent relationships include client-lawyer and employer-employee relationships. Canonical examples of principal-agent problems therefore can include representative democracy - where the voters are the principals and the politicians are the agents - and corporate management - where the company's shareholders are the principals and the company's managers are the agents.

An example of a principal-agent problem in engineering education might involve companies as principals with preferences for certain kinds of engineers they can hire and faculty members as agents tasked with educating engineers exhibiting the desired characteristics (e.g., good communication skills, technical proficiency, experienced with teamwork). A second example involves course TAs where the faculty member is the principal and the TA is the agent responsible for teaching or covering certain material typically selected by the course instructor. A third example might be textbook selection and faculty members who select expensive course textbooks – students are the principals who want to learn the course content but may not want to incur extra material costs faculty members are the agents who may not be concerned about the student's additional expenditures. Notably, in addition to a principal-agent problem in this textbook selection example, there is also information asymmetry, which illustrates the fact that these market failures can operate simultaneously. Other candidate examples abound given the number of bilateral relationships and interactions that exist within higher education.

Research into principal-agent problems in higher education could investigate how each member of the interaction perceives both their own and each other's role and responsibilities in the matter. For example, research could characterize the mental models of individuals in the engineering education ecosystem to see how individuals the principals and the agents mentally process their preferences and the alignment between each other's preferences. This could mean asking TAs and faculty member pairs how they shape their respective preferences and how they envision the principal-agent relationship. Another line of research could pursue a more traditional area in higher education research, looking at governance structures that affect engineering education. This would allow researchers to investigate relationships of power since these structures institutionalize some of these principal-agent relationships that could generate this type of market failure [41, p. 153]. The research would simply need to identify relationships of power, persuasion, and employment in order to focus on a principal-agent problem.

Accompanying the research dimensions, policy can attempt to balance these kinds of relationships by reducing the reliance of principals to depend on agents to achieve their goals. Policy can help ensure priorities and preferences align between the principals and the agents in order to prevent the gaps between those two groups' preferences. However, fully correcting this market failure could compromise the principle of academic freedom, which is central to the function of a university as a cultivator and protector of knowledge and ideas. For example, imagine the scenario above with companies as the principals interested in hiring engineers with certain characteristics and abilities and faculty members as the agents interested in educating engineers to possess different characteristics and abilities. Hypothetically, faculty members might refuse to adjust their preferences and practice, if it meant compromising their recognized expertise or professional values in order to align more with the companies' preferences.

Limitations of the paper

Possible limitations of the preceding analysis and the general discussion about market failures in engineering education fall into objections about being non-exhaustive and more fundamental conceptual issues. Regarding the initial kind of objection, there could be more illustrative examples to convey where each of the market failures could arise. Similarly, not only might there be better examples of the market failures but there could also be better policy and research examples other than those which we already mentioned. Instead of these being limitations, however, we suggest that this is a feature that invites readers into the conversation to think of their own examples and pursue their implications for areas in engineering education.

Regarding the deeper objection about conceptual issues, there are several. First, it could be unhelpful to frame education in this manner of markets. Doing so could eliminate important aspects of engineering education that are not amenable to economic analysis and therefore get swept under the rug in the name of manageability. Second, it is possibly inaccurate to frame higher education in this manner (i.e., this is a category error): treating higher education (and engineering education by extension) as a market good may be fundamentally flawed because there are no veritable markets for higher education in the traditional sense of containing representatives components of consumers, producers, and allocative efficiency [42]. And yet, a primary reason we have taken this conversation up in the first place is that the proverbial cat is already out of the bag; implicit market assumptions, whether helpful or unhelpful, accurate or inaccurate, are already informing everyday decision-making and long-term planning in higher education and engineering education worldwide.

On a basic level, some type of market treatment may be correct in that a financial transaction (or series of transactions) occurs between the student and the university at the end of which the student usually receives a diploma indicating their qualifications. On the other hand, one might easily argue that this simplified, unidimensional analysis falters in at least two ways. First, it arguably debases the meaning and value of education. As Oscar Wilde said, a cynic is someone "who knows the price of everything and the value of nothing" [43]. In that spirit, this economic treatment of engineering education may fall into a similar pattern of oversimplification and losing sight of the actual value of engineering education, confusing the price for the value. Second, the market failure analysis could normalize this market mentality that identifies markets in everything. Others have argued that this analysis vitiates multiple facets of life by exporting a specific logic from one setting to other areas where it is inappropriate. This type of criticism claims that the market-based analytic mode should have a limit because there are moral limits to markets [44].

Finally, there is also another philosophical problem previously alluded to. Namely, if market failures arise from inefficiencies then one must first determine what efficiency might mean in the context of engineering education before suggesting that inefficiencies exist. This objection arises because of possibly underspecified objective functions that arise from teleological inconsistencies/disagreements about the purpose of engineering education. Incompletely theorized agreements [45] that lack defined purpose(s) of engineering education then consequently obfuscates what efficiency even means in this kind of conversation about market failure in engineering education. This is not a fatal problem, however, because there could be several different purposes or definitions of efficiency in engineering education that would each then entail their own analysis and identification of market functioning and/or failure. Moreover, our present purpose was primarily to help the engineering education community remember that *if* there is a marketization of engineering education then there could also be associated market failures that warrant consideration. Likewise, this paper can serve as a warning of the perils that can befall unwitting or sanguine treatment of engineering education as a market good.

Conclusion

As universities, governments, and private organizations continue adopting market-oriented policies, there is a potential for these aforementioned market failures to arise. An awareness of their existence and potential negative effects can help the engineering education community respond quickly and effectively. Such responses could come in several forms. Researchers could further characterize and investigate the upstream causes and downstream consequences of the failures. Policy-makers could tailor solutions to redress these failures if/when they arise. Finally, engineering educators and students could have an additional lens for interpreting the events and extant policies around them and for understanding the logics that other actors employ within engineering and higher education writ large. Since this is a relatively new area of thought for the engineering education community, future work could attempt to identify the possible existence and effects of each of these market failures in more depth or re-analyze existing research under this lens of market failures. A separate avenue of research could adopt a more normative stance in order to determine which outcomes comprise efficiency and justifications for whether the treatment engineering education like a market good should be welcomed or resisted.

Acknowledgements

This material is partially based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-1333468. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

[1] D. King and S. Wood, "The political economy of neoliberalism: Britain and the United States int he 1980s," in *Continuity and change in contemporary capitalism*, Transferred to digital printing., H. Kitschelt, Ed. Cambridge, UK: Cambridge Univ. Press, 2006, p. 371.
[2] D. Harvey, *A brief history of neoliberalism*. New York: Oxford University Press, 2005.
[3] J. N. Cohen and M. A. Centeno, "Neoliberalism and patterns of economic performance, 1980-2000," *Ann. Am. Acad. Pol. Soc. Sci.*, vol. 606, pp. 32–67, 2006.
[4] D. S. Jones, *Masters of the universe: Hayek, Friedman, and the birth of neoliberal politics*. Princeton, NJ: Princeton University Press, 2012.
[5] I. Berlin, *Four essays on liberty*. London, UK: Oxford University Press, 1969.
[6] "Milton Friedman in his own words," *Becker Friedman Institute*, 2012. .
[7] D. D. Dill, "Higher education markets and public policy," *High. Educ. Policy*, vol. 10, no. 3–4, pp. 167–185, Sep. 1997.
[8] B. Jongbloed, "Marketisation in higher education, Clark's triangle and the essential ingredients of markets," *High. Educ. Q.*, vol. 57, no. 2, pp. 110–135, Apr. 2003.
[9] L. Lomas, "Are students customers? Perceptions of academic staff," *Qual. High. Educ.*, vol. 13, no. 1, pp. 31–44, Apr. 2007.
[10] G. Sharrock, "Why students are not (just) customers (and other reflections on life after George)," *J. High. Educ. Policy Manag.*, vol. 22, no. 2, pp. 149–164, Nov. 2000.
[11] D. B. Saunders, "Exploring a Customer Orientation: Free-Market Logic and College Students," *Rev. High. Educ.*, vol. 37, no. 2, pp. 197–219, Nov. 2013.
[12] M. N. N. Lee, "Restructuring higher education: public–private partnership," *J. Asian Public Policy*, vol. 1, no. 2, pp. 188–198, Jun. 2008.
[13] M. Ross and M. F. Green, "The American college president, 2000 edition," American Council on Education, Washington, DC, 2000.
[14] A. I. Morey, "Globalization and the emergence of for-profit higher education," *High. Educ.*, vol. 48, no. 1, pp. 131–150, Jul. 2004.
[15] T. T. Aldridge and D. Audretsch, "The Bayh-Dole Act and scientist entrepreneurship," *Res. Policy*, vol. 40, no. 8, pp. 1058–1067, Oct. 2011.
[16] S. Slaughter and L. L. Leslie, *Academic capitalism: Politics, policies, and the entrepreneurial university*. Baltimore, MD: Johns Hopkins University Press, 1997.
[17] S. Slaughter and L. L. Leslie, "Expanding and elaborating the concept of academic capitalism," *Organization*, vol. 8, no. 2, pp. 154–161, May 2001.
[18] G. J. Stigler and R. A. Sherwin, "The extent of the market," *J. Law Econ.*, vol. 28, no. 3, pp. 555–585, 1985.
[19] A. Sen, *On ethics and economics*, Reprinted. Oxford: Blackwell, 2003.
[20] R. Posner, "The ethical and political basis of the efficiency norm in common law adjudication," *Hofstra Law Rev.*, vol. 8, no. 3, Jan. 1980.
[21] J. L. Coleman, "Efficiency, exchange, and auction: philosophic aspects of the economic approach to law," *Calif. Law Rev.*, vol. 68, p. 221, 1980.
[22] J. Rawls, *A theory of justice*, Rev. ed. Cambridge, Mass: Belknap Press of Harvard University Press, 1999.
[23] F. M. Bator, "The anatomy of market failure," *Q. J. Econ.*, vol. 72, no. 3, pp. 351–379, Aug. 1958.
[24] W. W. McMahon, *Higher learning, greater good: The private and social benefits of higher education*. Baltimore, MD: Johns Hopkins University Press, 2009.

[25] P. Teixeira and D. D. Dill, "Introduction - The many faces of marketization in higher education," in *Public Vices, Private Virtues? - Assessing the effects of marketization in higher education*, P. Teixeira and D. D. Dill, Eds. Rotterdam: SensePublishers, 2011, pp. 3–17.

[26] D. D. Dill, "Through Deming's Eyes: a cross-national analysis of quality assurance policies in higher education," *Qual. High. Educ.*, vol. 1, no. 2, pp. 95–110, Jan. 1995.

[27] L. Robbins, *An essay on the nature and significance of economic science*. London, UK: Macmillan Co., 1932.

[28] J. B. G. Tilak, "Higher education: A public good or a commodity for trade?," *PROSPECTS*, vol. 38, no. 4, pp. 449–466, Dec. 2008.

[29] S. Marginson, "Higher Education and Public Good," *High. Educ. Q.*, vol. 65, no. 4, pp. 411–433, Oct. 2011.

[30] J. Stiglitz, "Knowledge as a global public good," in *Global public goods: International cooperation in the 21st century*, I. Kaul, I. Grunberg, and M. A. Stern, Eds. New York, NY: Oxford University Press, 1999, pp. 308–325.

[31] B. Daviet, "Revisiting the principle of education as a public good," UNESCO, Paris, 2016.

[32] G. Downey, "The local engineer: Normative holism in engineering formation," in *Engineering, Development and Philosophy*, S. H. Christensen, C. Mitcham, B. Li, and Y. An, Eds. Springer Netherlands, 2012, pp. 233–251.

[33] B. Weisbrod, *External benefits of public education: An economic analysis*. Princeton, NJ: Princeton University Press, 1964.

[34] J. B. Madsen and F. Murtin, "British economic growth since 1270: the role of education," *J. Econ. Growth*, vol. 22, no. 3, pp. 229–272, Sep. 2017.

[35] W. F. Maloney and V. Caicedo, "Engineering growth: Innovative capacity and development in the Americas," Social Science Research Network, Rochester, NY, SSRN Scholarly Paper ID 2932756, Feb. 2017.

[36] E. Cech, "Culture of disengagement in engineering education?," *Sci. Technol. Hum. Values*, vol. 39, no. 1, pp. 42–72, Jan. 2014.

[37] H. K. Ro and I. Bergom, "Why don't STEM majors vote as much as others?," *The Conversation*, 2018. [Online]. Available: http://theconversation.com/why-dont-stem-majors-vote-as-much-as-others-89015. [Accessed: 09-Feb-2018].

[38] K. J. Arrow, "Excellence and equity in higher education," *Educ. Econ.*, vol. 1, no. 1, pp. 5–12, Jan. 1993.

[39] S. P. Kulkarni, "Environmental ethics and information asymmetry among organizational Stakeholders," *J. Bus. Ethics*, vol. 27, no. 3, pp. 215–228, Oct. 2000.

[40] S. A. Ross, "The economic theory of agency: The principal's problem," *Am. Econ. Rev.*, vol. 63, no. 2, pp. 134–139, 1973.

[41] J. E. Lane and J. A. Kivisto, "Interests, information, and incentives in higher education: Principal-agent theory and its potential applications to the study of higher education governance," in *Higher education: Handbook of theory and research. Vol. 23*, J. C. Smart, Ed. Dordrecht, Netherlands: Springer, 2008, pp. 141–179.

[42] S. Marginson, "The impossibility of capitalist markets in higher education," *J. Educ. Policy*, vol. 28, no. 3, pp. 353–370, May 2013.

[43] O. Wilde, *Lady Windermere's fan*. Mineola, NY: Dover Publications, 1998.

[44] M. J. Sandel, *What money can't buy: The moral limits of markets*, 1st ed. New York, NY: Farrar, Straus and Giroux, 2012.

[45] C. R. Sunstein, "Incompletely theorized agreements," *Harv. Law Rev.*, vol. 108, no. 7, pp. 1733–1772, 1995.