How to cite:

Rodríguez Ortega, Nuria, Suárez, Juan-Luis, y Varona, Daniel. «Counting is not Enough. Modelling Relevance in Art Exhibition Ecosystems» *Curator. The Museum Journal*, vol. 63, issue 4 (October), pp. 637-653, 2020. First published: 22 September 2020 (posprint. doi: **10.5281/zenodo.10445083**).

Counting is not Enough. Modelling Relevance in Art Exhibition Ecosystems

NURIA RODRÍGUEZ-ORTEGA, JUAN-LUIS SUÁREZ, AND DANIEL VARONA

Abstract The authors present a conceptual and mathematical model for an *art institution relevance index* that quantifies the institution's ability to manage and leverage its loan relationships with other art institutions, art collectors, and curators. The propose that their model innovates on prior methods descriptions of institution relevance based on the depth or size of an institution's collections, by introducing a more complex combination of the institution's ability to manage the type, frequency and range of lending and borrowing practices. Their mixed methods approach is based on combining traditional methods of art history that have relied on subjective accounts of an institution's collection value with a more formalized methodological approach to quantifying what was once a discourse of practice. The show that a limitation in traditional approaches to evaluating institutional impact relied on subjective interpretation and is not scalable and therefore cannot account for the importance of the global art exhibition ecosystems.

INTRODUCTION

This paper contributes to the emerging research field of quantification and *datafication* of art institutions' practices and management through an examination and modelling of a case study representative of the dynamics of art exhibitions lending ecosystem at a global level. It does so by exploring the heterogeneous actors that dynamically interact to establish relevance of specific works and the practices of the institutions that own and maintain those objects. By adopting this context as a case study, the paper will illustrate how this new approach to museum practice can strengthen the perspective of conceptual and mathematical modeling in Art History and artistic culture, fields that have only recently been incorporated into computing and data processing practices (Baca, Helmreich, & Rodr´ıguez-Ortega, 2013, Baca, Helmreich, & Gil, 2019, Schich, 2016, among others), and responds to calls from the museum studies field to think more strategically about impact measurement (ie; Fraser, 2018).

Quantification may not be the most important criterion when evaluating art, museums or exhibitions, but quantification entered the cultural sphere a long time ago and remains one way of thinking about value. In recent decades, the measure of worth has often been reduced to quantification of readily available data like counting visitors or budgets, that seems to have become a new *modus operandi* for claiming impact. However, neither management metrics nor number of loans in an exhibition should displace well-reasoned complex arguments that are able to justify, both qualitatively as well as quantitatively, why a painting, an artist, an exhibition or a museum might be considered of the highest level, emotionally moving, or simply, very important for "le champ" of art (Bourdieu, 1992). It becomes more difficult to make sense of the production and relevance of the whole "field" of art when we base these arguments on purely semantic grounds, if only because the arguments for such an exercise would occupy thousands of pages to categorize the value of a global field that numbers over 55,000 museums and the exhibitions

they present each year[1].

With these large numbers, the most readily available alternative to make sense of how these institutions relate to one another is to create world rankings or lists that, in most cases, fail to be transparent enough about the type of data used, nor clear in what subjective decisions led to their creation. An assessment of the capriciousness of these lists inevitably creates what Eco (2009) describes as a reader's experience of vertigo.

We are aware that all rankings are built on value exercises and data availability that imply both choices and biases. We are also aware that mathematical models are just models that use certain tools to capture and represent a numerical reality that is also complex and nuanced. We know that every model is a political act that involves a specific understanding of reality and fosters a subsequent set of actions. Models employ sets of constraints that most often reflect the reality they are trying to replicate. Models are as valuable as the power of their explicability and expandability, and the quality and diversity of the data used to test and feed those models. In the case of the global art ecosystem, the exercise we propose can grow in value as it is socialized, modified and used by experts who deal in value judgements to explain the relevance of the domain and its actors. As with many other areas of society, the massive availability of data and the power of algorithms are starting to appear across the art world. In this context, we firmly believe that the lack of knowledge about data and modelling, and the mere resistance to produce internal-to-the-domain models will result in externally driven or imposed models that are not as useful to institutions, and may even diminish the art expert's ability to keep employing discourse and qualitative criteria to establish relevance. We make this claim while also bearing in mind that our model may not be well-received by segments of the art museum ecosystem, especially those whose background was shaped by current scholarly traditions of qualitative-subjective interpretation. Nonetheless hope that our proposal begins a conversation about these issues. We advocate for the need to build a new hermeneutic as synthesis between the quantitative and qualitative instead of maintaining a fight between polarized and binary categories.

In almost all aspects of our current digital lives, a value or measurement has been assigned to most human actions thanks to the millions of data points that we daily produce, and the increase in computing power along with increased capabilities of hardware processing. The result is that virtually all aspects of our lives are now susceptible to being described through metrics; that our behaviors can be framed through predictive models; and that our value systems are being actively shaped according to scales and rankings computed by algorithms (Merry, 2016). These scales and rankings become epistemic and axiological instruments that, along with the current available tools, serve to articulate certain forms of knowledge and notions of relevance. Furthermore, they are used to build narratives about value, what is considered valuable or important, and what deserves to be the object of attention (Mazzucato, 2018). The negative consequences of this "algorithmic life" (Amoore & Piotukh, 2016) have already been felt across numerous aspects of life: the interference in democratic elections; disturbing issues of privacy and surveillance; and the creation of new regimes of economic dominance based on data-based knowledge and marketing systems. This sort of quantitative axiology that increasingly governs our lives is not trivial if we bear in mind that these rankings have a direct effect on people and communities as they can influence their behavior, economies, aspirations, frustrations and vital goals. Hence, contributing to the development of a critical discourse that focuses on the very concept of value, and how it might be quantitatively modeled, is one of the crucial challenges of our time.

We need to reflect on what "being relevant" means in order to explore the different dimensions of relevance from diverse positions, and especially to critically rethink what notions of relevance are being modeled and measured by each algorithm and index designed for such purposes. This reflection has a special significance in the fields of arts and humanities: most of the knowledge produced in these fields inherently involves an axiological component since it is constructed by means of judgments through which the "artistic", "literary" or "cultural" values of human production are determined and evaluated. We argue

that by not engaging critically with data-based systems of relevance –as they intersect with culture and the arts in practical, concrete terms–eventually results in the imposition of such systems by market driven forces external to the domain in question, in this case, the ecosystem of art institutions.[2]

Furthermore, in the field of art, the establishment of orders and hierarchies of relevance among artists, curators, artworks and institutions is an intrinsic practice of the art system, as it refers both to the influence of critics, the building of the canon, and our systemic biases. However, the determina- tion of notions of relevance in this area has been carried out so far through discursive, social, and insti- tutional negotiation practices, responding to the well-known formula coined by Dickie (1974), which assumes that art is what the art system says art is. Analyzing how the relevance values of the art system are challenged by the parameters based on algorithmic modeling, which are exogenous to the art system's discursive practices, should be of great interest to the actors participating in the system. This interest resides both in the new knowledge that this analysis will enable us to produce about par- ticular aspects of the art domain, and in its capacity to act as a hermeneutic and a critical tool to uncover the categories of relevance themselves that will be used by art discourses.

Along with the notions of relevance and value mathematical models and metrics, when appropri- ately designed, allow us to quantitatively characterize structures and processes of the cultural domain by unearthing much of the domain's intrinsic complexity and its operating logic at a global scale. Fur- thermore, metrics and mathematical models can also become valuable tools to assist political and

managerial decision making as they reveal hidden trends, biases and/or unnoticed patterns of behav- ior across quantities of data that the human mind is unable to process.

The question here is not simply about the application of mathematical models –otherwise pre- sent in all aspects of human life– to the cultural domain because it is trendy everywhere else. The main issues art historians, museum administrators, and curators should concern themselves with is that this type of quantification of reality (Crosby, 1997) is usually taken by reality itself and used as the only criterion for decision making at the artistic, social or political levels. Knowledge of the tools of data and quantification, their reach, limitations, and possibilities seem to be the best manner of delimiting its proper use when arriving at areas of expertise not exposed yet to its transformative powers. But to exercise this judgment based on proper criteria requires the critic to engage in what it means to quantify reality, what quantification says and does not say about that quantified reality. It is also vital that we admit what quantification will never be able to tell us about a specific human domain. More than ever, the tool-set of "the discreet one" (Gracia´n 1646) needs to be extended if s/he wants to keep exercising reasoned judgement.

Hence, in conjunction with critical discourse, it is also important to adopt a proactive attitude aimed at the development of meaningful mathematical models capable of providing new understand- ings of social and cultural phenomena in the age of *datafication*. But in order to remain both meaning- ful and useful, these new understandings need to make transparent the logic, data and assumptions that govern the metrics and rankings they produce. The challenges of measurement, reliability of metrics, interpretability of indicators, etc. are well known and have been extensively discussed (Muller, 2018).

Related Studies

For the past decade, several scholars have been trying to model the "soft power"[3] of arts institutions.

For instance, Grincheva (2019) proposed a new methodological framework to measure "soft power" using geo-visualization. In her study, she defines "soft power" as the ability to mobilize and

attract larger audiences, while generating significant economic activity, and developing stronger relationships with a wide range of constituencies locally, regionally, and abroad. The main goal of her study is to find novel methods for evaluating how museum's collections, global networks and, and programing contribute to higher 'soft power'. Building in part on her study, we are formalizing several factors – Infrastructure, Classics measures, and Networks – related to Grincheva's study, and thus enriching the qualitative discourse around art institutions with objective indexes.

In the book "Museum Marketization: Cultural Institutions in the Neoliberal Era" edited by Ekström (2019), two entire sections are dedicated to address the gap between the artistic and business side of running art institutions, and the subsequent exercise of rethinking museums role. Both sections of the book highlight the impact of single museums in the global network in an environment described by increasing competition, governments cuts, and a significant need for new forms of funding. We think that having a formalized model of relevance may assist institutions to bridge this gap by becoming self-aware of their impact in the local, regional and global art institution ecosystems. This formalization will help them to identify the areas, efforts and resources that need be redirected when aiming to increase their own 'soft power'.

Art institutions must keep the pace emerging technologies are bringing to the art landscape, where a single geographically isolated institution might significantly attract larger audiences and develop more programs just by taking advantage of digital scenarios. Here we reference the dynamics of lending relations as characterized by Zamora-Kapoora, Frédéric, and Zhaoc (2020). In that work, they characterize how art institutions networks are based mainly on lending relationships that move these institutions toward an internally reference-based paradigm that will only grow its importance. That research includes a critique to classic institutions, historically perceived as leaders within the art ecosystem, but notes that their involvement in the current exhibition ecosystem might need reassessing as object and artist values shift. In that regard, our work explores this thinking, first by focusing on tangible factors such as museums role as lenders and borrowers, and curators' roles as participants shaping the formation of these ecosystems. We also include many other less tangible variables that are being currently formalized as constrains and that we hope can expand the model in future refinements of our project.

Following Camarero, Garrido, Vicente, and Redondo (2019), our model is also interested in understanding whether art institutions relations are more linked to specific governance style or if it is the strong participation of given curators that shape those relations. That 2019 study followed a traditional approach surveying several well-stablished curators from well-known art institutions in the EU, USA and UK. It is important to note that even when we chose a different approach, we both arrived at a common base, with Camarero's outcomes aligning with the elements we took into consideration for our model before reading their publication. In addition, both Camarero's and our model emphasize the need to evolve theories of social capital as applied to museums based on lending relations.

While our model was mainly concerned with curators and institutions, we wanted to also note the work of Sukran and Jaewoo (2020) who are following a very closely related research area. In their work, they acknowledge there exist certain differences among the visitors with regards to the generation they belong to and their interests towards specific exhibitions. They also defined a "return rate" index to measure museums' performance -which might be another way for perceiving relevance and demonstrated that tailoring the exhibitions to comply with the targeted generational visiting sector does actually improve the museums' performance and exhibition attractiveness. In our model, we did not take the exhibition nor institution´s targeted audiences into consideration as a main variable, however we did leave room for decision-makers and institutional leaders to incorporate such variables as parameters when evaluating the city relevance if they consider it applicable to their specific sce- nario. That way the Sukran and Daewoo's idea of "what service should be provided for whom" is not compromised in our proposed model.

Proposing a model to objectively evaluate relevance within the context of art exhibitions also finds support in a need recently highlighted by Orea-Giner, De-Pablos-Heredero, and Vacas Guer- rero (2019) as they refer to the integration of both qualitative and quantitative analyses into a single method to assess different metrics like sustainability, economic value, and socio-cultural impacts of art institutions. Their approach was theoretical and showed the fundamentals for further research such the one we propose here.

Being aware of the type of proposal we are promoting we also took into consideration some ethical concerns that might arise around using mathematical models when making decisions regarding art and art institutions. Specifically, we analyzed those ethical concerns in Wilson (2019). Consequently, we explicitly declare our work is not intended to be use in any decision-making regarding art institutions hegemony. Our intention is to provide a mechanism to support and to enrich the current art institution stakeholders' understandings which right now is mainly empirical, and experience based.

We understand that the present study may be perceived not only as an interdisciplinary proposi- tion, but also as a provocation by many stakeholders within the art ecosystem, specifically curators. In that regard our work, as in Schorch and McCarthy (2019), intends to highlight the transformation of the role of the curator from being an expert into becoming a mediator between art institutions, and between people and art objects, while they remain to be critical actors in the exhibition ecosystem. As we are aware that a curator's relevance index might be a sensitive issue for some, we make it clear within the final part of the description of the model that it is decision of the ecosystem's evaluator in each case to fold or not a curator's relevance index into the institution's relevance overall final evaluation.

Weighting in the Art Domain

The approach we are proposing is not new. For example, the quantification of visitors, the most universal indicator used so far to measure the relevance of cultural institutions, although not exempt from some controversy, has a long history of becoming a crucial factor in the decision making in the field of cultural management and funding. However, in the course of the last decades, the art realm has experienced continuous global expansion in an exponential growth process that has seen the appearance of new museums, biennials, fairs, etc. Faced with this increasingly complex and expanded scenario, we deem it necessary to develop new metrics and models that address the challenges posed by a hyper-connected and hyper-entangled global society.

The art market has understood this situation quickly and started a reinvention process in which the growth of the field has been accompanied by the emergence of numerous service platforms that base their business models on data processing and analytical consulting, for example, MutualArts[4], ArtFacts.Net[5], Artsy[6], among others. These platforms offer all types of indexes, metrics and rankings that materialize certain hierarchical orders of relevance and value. Defining a state of the matter is complex, because most of the algorithms used by these companies are proprietary, closed, and secret, making the operating logic opaque instead of transparent. However, we can use the ArtFactsNet model as an example since the company offers a brief explanation about its model on its website[7]. This model seems to be based on the weights of each "famous" artist.

Here, famous artists are those exhibited in international exhibitions, events and institutions8. Consequently, the index of an artist is derived from the number of exhibitions in which he/she has been featured, with each exhibition weighted according to its "international" dimension. There is no explanation of what is meant by "being international" or how it is measured. The relevance index of the artists expressed in a ranking is used to establish the relevance index of the exhibitions, the institutions, and the cities. Without going into details about the recursive nature of this model, it can be said that the notion of relevance in the ArtFacts.Net algorithm is related to the capitalist-based concept of the "economy of attention" as defined by Franck (1999). In addition, it also defined by the contemporary discourse on the global economy that makes "internationality" an essential parameter of

valuation, taking into account that in this model "internationalization" acts as an extra-systemic parameter (Rodríguez-Ortega, 2018).

Examples of the application of quantitative methodologies to interpret the art exhibition ecosys- tem from different perspectives are also found in the scholarly field. Thus, the team headed by Albert-László Barabási has recently developed a predictive model based on mapping out the co-exhibition network that captures the movement of art between institutions (Fraiberger, 2018). Centrality within this network is interpreted as institutional prestige, "allowing to explore the career trajectory of individual artists in terms of access to coveted institutions". The research reveals that artists' reputation and success are strongly dependent on receiving early access to institutions considered relevant, so that the earlier the access, the faster and greater the success. An important consequence of this quantitative study for art institutions is that the verification of this structural mechanism determining the construction of an artist's career, which goes beyond the artistic skills and/or aptitudes, fosters the need to rethink the policies put into play by museums and galleries in order to rebalance artists' opportunities.

CONCEPTUAL AND MATHEMATICAL FORMALIZATION OF AN ART-EXHIBITION ECOSYSTEM

The main questions that we pose in this paper are: what other dimensions of "relevance" that have not been previously considered might be explored in the art exhibition ecosystem? How can they be modeled independent of extrinsic factors? What knowledge could be extracted from it in relation to the configuration of such a system? How might this knowledge affect the re-evaluation of policies, decision-making and initiatives put in play in the art exhibition ecosystem?

This publication is not intended to propose a closed unique and universal index of evaluation of the art domain. Our goal is to propose a first method to evaluate the relevance of a given aspect of the artistic domain that so far has only been considered in qualitative terms: the processes of artistic circu- lation in exhibition ecosystems.

Our approach assumes that the art exhibition ecosystem has a network structure, in which the exhibitions act as the cultural devices that allow for relationships/connections between heterogeneous actors (institutions, artists, curators, collectors, etc.)[9] (Figure 1). These relationships/connections build and articulate the system in a certain way through a behavior's logic, which can be traced within this instance of a cultural network[10].

Among the various connections that constitute this networked system, we have made the epistemological decision of using the quantification of the loan relationships between institutions as one of the fundamental measures of the relevance value. We are aware that this is not the only parameter that we could have selected, given that other aspects, such as the ability of certain curatorial discourses to transform the perception about artistic concepts, are also important in assessing dimensions of relevance in the exhibition ecosystem. However, we considered that exhibition loans deserve special attention for the following two reasons: First, they allow for the circulation of works and thus, the publicizing of artists with the consequent processes of artistic transfers, expansion of the visual imagery made available to locals and visitors, and the dynamization of the system. The analysis of

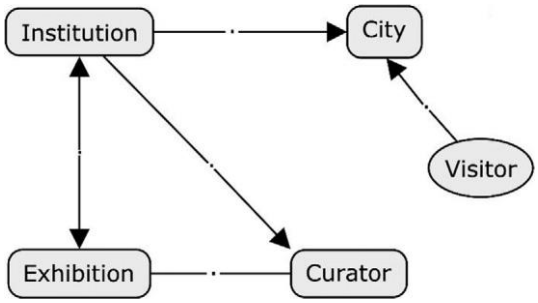

Figure 1. Simplified art exhibition ecosystem model. Own contribution; not reproduced from another source.

processes of artistic circulation has become a key element in the studies comprised within the Global Art History field, which have focused their interest on the mobility of artworks, actors, ideas and practices by considering their effects and consequences from a transnational perspective (Da Costa Kaufmann, 2015). Therefore, adopting the loan relationships as a proxy measure for relevance adds value to our understanding of this ecosystem, as it allows to further investigate the logic that defines the mechanisms underlying the art-cultural circulation and transfer processes.

Loan relationships also allow for the construction of aesthetic and theoretical–critical discourses proposed through exhibitions, which require the presence of certain works in order to be articulated in certain ways. Consequently, the configuration of the art exhibition ecosystem as a discursive construction is especially dependent on these loan relationships, which will determine the possibility of the existence (or not) of certain narratives and stories. It is fundamental for the *resemantization* of institutions' collections of cultural and the addition of new value to them.

The *Code of Good Practices of Museums and Art Centers* operating in Spain, establishes the notion that loans constitute an indicator to assess the relevance of cultural institutions. However, an index for the evaluation and measurement of relevance based on loan relationships has not been proposed to date. Our proposal relies on a conception of the art exhibition ecosystem, defined fundamentally as a space for circulation and transfer, that focuses on the connections that act as its backbone. We can derive from the above argument that institutions and collectors that participate in the loan relationships are key actors in the configuration of the mentioned ecosystem. The outgoing and/or incoming connections involving a cultural institution in any given exhibition express the dynamic role that institutions and collectors play for processes of artistic circulation and transfer. Furthermore, the outgoing connections determine the significance of certain art collections for the articulation of contemporaneous discourses. In turn, the incoming connections prompt the financial capacity and reliability value of the institutions, their adequate management, and risk control. In a political-economic con- text in which museums are forced to demonstrate their usefulness (Fraser, 2018), having metrics that help us to weigh the role played by museums in different dimensions, such as the loan relationship policies, will provide a valuable instrument to assess the usefulness of museums as a dynamic agent of the exhibition circuit.

Following this assumptions and decisions, our aim can be encapsulated as follows: how can the relevance of an institution be weighed in an art exhibition ecosystem based on loan relationships? Equation (1) models the relevance index of an institution throughout the loan connections it has at any given moment.

$$Wi\begin{cases} if\ NR_{en}\ \neq TR\ ;\ Wi\ =\ \dfrac{{NR_{ex}}^{p}}{{NR_{ex}}^{p}+\ TR}+0.9\left(\dfrac{{NR_{en}}^{p}}{{NR_{en}}^{p}+TR}\right)+0.05 \\ if\ NR_{en}\ =TR\ \|\ NR_{ex}\ =TR;\ Wi\ =\ \dfrac{{NR_{ex}}^{p}}{{NR_{ex}}^{p}+\ TR}+0.9\left(\dfrac{{NR_{en}}^{p}}{{NR_{en}}^{p}+TR}\right)-0.05 \end{cases}$$

where: *Wi*: weighted index for a given institution. NR_{en}: number of incoming connections. NR_{ex}: number of outgoing connections. *p*: numerical value. *TR*: total number of institution's connections.

Although the presence of both outgoing and incoming connections is important because it describes a dynamic, active, and trustworthy actor in the circulation and transfer processes, we have assigned a greater value to the outgoing connections given the prevalent role they assume, which allow for the very existence of the relationship. Thus, in the mathematical equation, the multiplica- tion of the incoming connections by 0.9 distinguishes their lesser weight in contrast to the outgoing connections. Consequently, outgoing relationships always have a greater weight in the configuration of the relevance index. We must point out the value of 0.9 was not arbitrarily determined. We used a set of virtual scenarios which covered all the restrictions from the ecosystem behavior we aimed to model; then 0.9 was the only value in the range [0.1–1.0][11] that produced a result that met the sorting requirements dictated by the ecosystem behavior[12].

The exponential function has been incorporated to add value to the volume of connections, which is important when the model becomes sensitive to that volume. A greater number of connec- tions indicate a greater institution's capacity to engage in the articulation of the exhibition ecosystem and, thus, this institution should have a higher relevance index. However, we decided to let the value for the exponential variable *p* be at the evaluator's discretion while executing the model. That way, the evaluator will have the liberty of adjusting the speed (and range amplitude) in which the exponen- tial growth of the function will be projected.

We have also considered another circumstance in our model: the existence of institutions–-nodes with only one type of connection (incoming or outgoing)[13]. In these cases, the full relevance index relies on the single set of input or output connections they have. As indicated, this circumstance poses a mathematical problem because if we apply the algorithm as the simple sum of the normalized number of outgoing and incoming connections, the relevance index for these institu- tions would always be 1. Consequently, these institutions would always have a greater relevance index than institutions with two types of connections, which would be thus "penalized" just for that reason. However, the capacity to articulate the two types of connections is potentially an expression of dynamism in the artistic circulation processes since they can generate loan relationships from both directions.

To solve this problem, a constant (0.05) has been added due to recognize the dynamizing capacity of the nodes with two types of connections. Hence, in the mathematical formula, the sum/subtraction of 0.05 acknowledges the articulatory ability of institutions within the cultural environment.

Consequently, the *Wi* acquires values between −0.05 and 1.95 according to Equation (1). The values of *Wi* that are closer to 1.95 indicate the greater relevance of an institution compared to other institutions within the network.

The application of this algorithm will establish a hierarchy of the relevance index, which will behave with the following logic: given a similar volume of connections, the institutions with a double connection type will have a higher relevance index, which will elevate them according to the volume of

their connections. Among them, those with the greatest number of outgoing connections will even reach a higher value. Institutions with only one type of connection will have a lower relevance index, which will elevate them according to the volume of the connections. Among them, those who only receive loans will exhibit lower values of the index. This formalizes the conceptual reasons explained above, even in the few cases that can occur when an institution received a very high number of art- works because, for example, its function in the art field is to make exhibitions with works from other institutions (i.e., art centers without their own collections that must borrow works from other centers).

Faced with a volume of very different connections, institutions that have more connections, regardless of the direction, will have a higher relevance index; meaning they are more active in favoring the exchange within the art context.

Known Constraints

The authors are currently defining further elements to be incorporated in next iterations of the model such as the practice of commissioning (now folded within the modelling of curating), the weight of the artists beyond that of their works, and a certain type of unique art institution. This type, represented by the cases of the Venice Biennial and Documenta, just to name two of them, are proto-typical of the importance of the exhibition ecosystem to the whole art field. These institutions are fully devoted to exhibit works, but instead of borrowing (in principle, they never lend), they mostly commission the works they exhibit, playing the equivalent role to islands in natural ecosystems, which follow a specific evolutionary logic. This addition will allow us to face another problem currently not covered by the proposed model, that is, the processes of artistic production as basis of the dynamics of art exhibition ecosystems. The other distinctive feature of these cases is that they only exist in time if the exhibitions they sponsor do, that is, their lifetime each cycle is that of the exhibit[14]. It is necessary to point to two more themes that were not used in this model, but will be shortly integrated in a future iteration: first, the nuanced role that specific museums, some of them normally considered top institutions, but also those which have very specialized collections, in controlling sup- ply of certain artists and works into the exhibition ecosystem. It might be also the case that a museum is very influential because of its permanent collection, even though its participation in the exhibitions' ecosystem is minimal because of strategic reasons, such as the condition of its works or because most of its exhibitions are built from within its own collection. In fact, the model we propose can be an interesting instrument to discriminate between these dimensions of relevance, distinguishing between the role played by museums due to the value they hold by their collections in the art system, and that played for their participation in the loan processes and, therefore, in the dynamization of the artistic ecosystem. These two dimensions of relevance might coincide in the same museum, but it does not need to in all cases. In this sense, it is important to note that the model we propose only focuses on a dimension of relevance and that, therefore, this should not be taken as an indicator of less relevance in those institutions that, due to their own nature, had a lower volume of loans: for example, non-collecting institutions or institutions with collections that are too delicate to travel. Naturally, these institutions could be considered less influential in terms of dynamization processes based on loan relationships, but this consideration should not dismiss their influential role in other dimensions of the art exhibition ecosystem or the art system in general.

Second, the domain of museums and art exhibits is not uniformed across cultural boundaries and market jurisdictions: metrics such as number of visitors and other measures based only on counting might require adjustment in their weight within the model in certain sub-ecosystems.

Refining the Model

Finally, having made these clarifications, we can proceed to explain that institutions with no connections will rank a relevance index of −0.05, presented as null actors in processes of artistic circulation and transfer.

Complementarily, we have used two variables to determine the weight of an institution beyond the structure of the network, which will allow us to balance the previous index according to social and economic criteria that affect the performance of institutions in a fundamentally globalized economy (Figure 2).

First, the (effective) attention received by the institution is measured by the annual number of visitors, even if we are aware that sheer numbers of visitors do not talk to the quality of their interactions with art works, as shown by the fashionable selfie trend present in museums in recent years. The visitor index *Iv* is formulated as follows:

$$Iv = \frac{v_i}{TV_r} \tag{2}$$

where: *Iv*: Index of visitors of a given institution. V_i: Number of visitors of a given institution in a period. TV_r: Total number of visitors registered for all institutions being analyzed for the same time period.

Second, the (potential) attention is based on the weight of the city where the institution is located. The weight of the city (*Ic*) is determined by a previously established scale (see Table 1), which is populated using parameters including but not limited to: the number of inhabitants, the type and number of access infrastructure that facilitate the circulation of people, etc. The scale may be adjusted in accordance with the complexity the modeler wishes to add into the analysis. This also

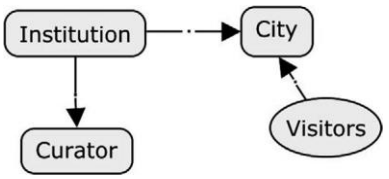

Figure 2. Conceptual model for the impact index (Mi). Own contribution; not reproduced from another source.

Table 1.
Parametrization scale for cities. Own contribution; not reproduced from another source

Evaluation	Parameter
	<Parameter one.. .>
	<Parameter two.. .>
	<.. .>
	< Parameter n.. .>
Total	< Value>

allows to calibrate the positioning of art institutions as global actors in an exhibition ecosystem that emerges out of local and global connections.

Each parameter in Table 1 must be evaluated in binary terms; those parameters met in the con- text will score 1 and those which do not will score 0. Then, the scale value follows a process of normal- ization so that the remaining elements on the Equation (4) will not be unbalanced hereafter. Equation (3) will provide the weight of a given city (*Ic*):

$$Ic = \frac{TV_i}{TPV_r} \tag{3}$$

where: *Ic*: Index of a given city. TV_i: Total value achieved by the parameters that where met by the city. TPV_r: Total possible value a city may meet given the complexity of the analysis.

Consequently, the impact of a given institution (MI) is modeled as Equation (4):

$$Mi = Wi + Iv + Ic \tag{4}$$

This impact index can be a parameter to measure the relevance of the other actors in the ecosys- tem whose activity is directly related to the institutions, as it is the case of curators. The participation of curators is formulated here as the sum of the incoming connections received from institutions, each one being weighed by the impact index of the institution.

Hereafter, the Equation (5) models the weight of a given curator as follows:

$$W_{AC} = \sum_{n=0}^{n} (NR_{EN} \times Mi_n) \tag{5}$$

where: W_{AC}: weighted index for a given curator. NR_{EN}: number of relations a curator receives from an institution in the position n among those connected with the given curator. M_i: weighted index for the institution in the position n among those connected with the given curator.

If the decision maker prefers a different approach to the same W_{AC} in which the resultant value is not a global representation of the involved variables, but a vector of such variables instead,

Equation

(6) provides the way to do so:

$$W_{AC} = \sum_{n=0}^{n} (NR_{EN} \times \{Wi_n \quad Iv_n \quad Ic_n\}) \tag{6}$$

The result representation of Equation (6) will be a vector of three variables. As a vector, this will allow further analysis on given individuals and on groups of individuals within the considered sample.

This formulation can be used to measure the participation of other actors within the art exhibition ecosystem just by adapting the parameters to be considered.

Validation

In order to validate the proposed model, we defined 4 different datasets, three of which were virtual datasets, representing all the restrictions the model will have to meet. The fourth data set consists of a sample of actual data we have gathered from the available data belonging to art institutions in Spain in a given period. For that, we used the Expofinder system, which comprises a large data repository of exhibitions held in Spain during the 20th and 21st Centuries (Rodríguez-Ortega & Cruces-Rodríguez, 2018). We also ran stress tests by changing the number of connections, exploiting scenarios in multiple order of tens and over millions of connections. First, we ran dozens of institutions, and then hundreds of institutions, to assess the sensitivity of the model. In all cases the model reached a sorted list of values with the expected distribution, with a time response of less than one minute, showing no significant differences among all tests' execution times.

We decided to document the results of the application of the model in further communications as this is still an active research project, and we are still gathering more data from Spanish art institutions.

DISCUSSION

The application of Equation (4) to a given dataset will result in a hierarchical index of institutions within the art exhibition ecosystem according to the value of its impact index (Mi). However, and beyond the ordering itself, the interest of these ranking mechanisms lies in their heuristic value, that is, in their capacity to trigger questions by unveiling aspects of the functioning of the art exhibition ecosystem that have gone unnoticed.

It is expected that the institutions with the highest impact index are those that the art system recognizes as "relevant" institutions as a result of traditional discursive practices about the value and importance of museums, their histories, their collections and their exhibits. Likewise, it is expected that the institutions with the lowest impact index are the ones considered as "minor" in the context of the art system, either due to their size, scarce financing capacity, local scope, insignificant or unknown collections, etc. However, we anticipate that the location of institutions that are traditionally considered as important by the art system in a low–middle place of the scale will provide us with information about their role in circulation and transfer processes. More importantly, this will open-up some relevant questions that would lead us to consider the conditions governing their exhibition policies (if they are too focused on exhibitions based on own collections), and/or the conditions of their loan policies (if they are too restrictive to effectively facilitate the circulation of artworks and artists).

The model we propose can be an interesting instrument to discriminate between different dimensions of relevance, distinguishing between the role played by museums due to the value of their own collections, and the role played in the dynamization of the artistic ecosystem. Both dimensions of relevance might coincide in the same museum.

Our relevance index should not be used for diminishing non-collecting institutions or institu- tions

with collections that are too delicate to travel; the latter are less influential in terms of dynamiza- tion processes based on loan relationships, nevertheless, they have an influential role in other dimensions that we will incorporate in the model and communicate in further publications.

The use of the three variables in the modeling of the impact index and the possibility of observing their behavior independently will give us the opportunity to examine how the position of an institu- tion changes depending on which variables are taken into account and, consequently, how the possi- ble discourses around a given actor shift depending on the dimensions of meaning activated by various parameters. Thus, an institution with a relevance index of -0.05 and with an average position in the general ranking of (Mi) is conveying that its position relies on external factors, which can be considered independent from its role as an articulatory actor in the network system.

The application of Equations (5) and (6) to specific datasets can be used to express a ranking among a set of curators within a network showing the art institutions they are connected to. This rel- evance must be understood in relation to the concept of the art exhibition ecosystem that is the basis of our modeling and, particularly, in connection with the "circulatory" value of relevance that we are proposing and not in absolute or global terms.

The possibility of disaggregating the relevance index of a given curator according to each of the indices applied in the (MI) of the institutions, such as Equation (5), will allow us to analyze how the position of curators varies according to their relationship with more or less dynamic institutions as far as the circulation processes are concerned, or according to their relationship with institutions that receive a given degree of attention. The results obtained may also be relevant when hypothesizing the role played by the curators –as the creative forces of the discourses conveyed by the exhibitions– according to whether an institution has a greater or lesser relevance index. Furthermore, the connec- tions of curators with institutions located in cities with a high index would also suggest their greater international projection and their greater capacity for impact.

In addition, the notion of relevance that is shaped and measured by our model will endorse muse- ums adopting new values related to the service they provide to the community beyond the now stan- dardized visitor counts. Even more, we hope the model we propose in this paper will become just one of the mechanisms used by museums to put in practice the perception that they have of themselves and of the role they want to play within the art exhibition ecosystem.

We think that this type of modeling illustrates better than simple counting metrics -like the number of patrons to a show, the number of works in an exhibition or the total monetary value of a collection- the richness of the interactions many art institutions engage in as part of their values and missions. Many of the current metrics used in museums and art galleries today miss the complex interrelationships that emerge from the activity of the global art ecosystem because these inherently rich art interactions require variable rich tools that reflect their complex and relational reality.

Similarly, we encourage decision-makers and future designers to consider extending the model to include city and regional infrastructure, as explained in section 4, as one of the parameters when populating the parameter matrix for evaluating a city's relevance. We make this recommendation with awareness of the research by Campa, Pagliara, Lopez-Lambas, Arce, and Guirao (2019) as an example of how measurements of impact that high-speed rail on an area's cultural tourism also flowed to museums. These two examples do not exhaust the variables that our research project team is that can expand future iterations of the proposed model.

CONCLUSION

We hope that a proper level of engagement in this type of modelling can expan and understand- ing of how the actors in the art ecosystem make many of the decisions about the parameters and vari- ables to be considered in a global valuation exercise. For instance, by assessing the role of web visitors as an important variable in a post-pandemic scenario. We hope that this work will help institutions and experts alike to align their artistic and political values with business quantification models that can reveal and identify possible indicators of the tangible impacts their work has on the art ecosystem and society at large.

FUNDING

This research was funded, in part, by a Canada's Social Sciences and Humanities Research Council grant on hybrid cultural networks, the Ministry of Economy and Competitiveness (Spain) under the grant number HAR2014-51915-P] and by the Centro de Estudios Andaluces (Junta de Andalucía) under the grant number PRY128-17.

NOTES

1. In the case of higher education, university rankings have produced little surprise about which universities and departments are considered best in the world, confirming Bourdieu's ideas (Bourdieu and Dubois, 1999) about the weight of incumbents in any field. It takes a long time and a continued effort to move positions in those rankings, although some Asian universities are starting to experience some upward movement. For most universities, these rankings are useful only in as much as they reflect some numeric values and relations on principles and goals that they have set up for themselves, or they need to report on.
2. Some examples of these new business models based on algorithmic rankings concerning the art exhibition domain are provided in section two.
3. "Soft power" seeks to express a measure of how museum collections and global networks in which museums operate produce value. It is a subject that many researches agree has not been properly explored either in academia or in practice.
4. https://www.mutualart.com (accessed on May 25, 2019)
5. https://artfacts.net (accessed on May 25, 2019).
6. http://www.artsy.net (accessed on May 25, 2019).
7. https://www.artfacts.net/index.php/pageType/ranking/paragraph/3 (accessed on May 25, 2019).
8. Hereafter the term "institution" also includes collectors and all those cultural agents that participate in loan relationships.
9. For a more detailed model, see Rodríguez-Ortega and Cruces-Rodríguez, 2019).
10. The model is open to the inclusion of new features that captures other complexities such as the importance of schools and artists in this ecosystem. These dimensions have been very fruitful in similar projects as described by Suárez, J.L., F. Sancho Caparrini, J. de la Rosa (2011): https://ieeexplore.ieee.org/document/ 6103208.
11. We looked into the values comprehended between 0.1 and 1.0 in order of not affecting the normalization to what the equation its exposed to and consequently reaching an unaltered result.
12. http://www.expofinder.es (accessed on May 25, 2019).
13. Ensures that with an approximately similar volume of connections, institutions with two types of connections (incoming and outgoing) always have a higher relevance index than the nodes with a single type of connection; at the time distinguishes exiting connections over the entering connections. The sorting will present a four-quartile ranking with the following distribution: 1st Q Nodes with

greater number of exiting connections, 2nd Q Nodes with greater number of entering connections, 3rd Q Nodes with only exiting connections, and finally the 4th Q exhibiting Nodes with only entering connections.

14. We thank the reviewers for their suggestions in this matter.

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