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Abstract

This study investigates agglomeration effects for classical music production in a wide range of cities for a global sample of composers born between 1750 and 1899. Theory suggests a trade-off between agglomeration economies (peer effects) and diseconomies (peer crowding). I test this hypothesis using historical data on composers and employ a unique instrumental variable – a measure of birth centrality, calculated as the average distance between a composer's birthplace and the birthplace of his peers. I find a strong causal impact of peer group size on the number of important compositions written in a given year. Consistent with theory, the productivity gain eventually decreases and is characterized by an inverted U-shaped relationship. These results are robust to a large series of tests, including checks for quality of peers, city characteristics, various measures of composers' productivity, and across different estimations in which also time-varying birth centrality measures are used as instrumental variables.

JEL Codes: D24, J24, N90, R12, Z11

Keywords: agglomeration economies, density effects, peer effects, productivity, urban history, cities, composer

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1. Introduction

Agglomeration economies are widely believed to be beneficial for a person's development and productivity. This is, however, arguably only true to a certain point, when agglomeration diseconomies come into play and outweigh any arising benefits. These are the forces which enable cities to grow but keep them from becoming too large. While it is one of the core concepts within economics, surprisingly little is known about the efficient agglomeration size. There is also only limited empirical evidence on the magnitude of agglomeration economies and diseconomies (Cingano and Schivardi, 2004).

The causal effect of density on productivity is a central question in economics, as it is key to many explanations of city growth and the spatial organization of economic activity. As a result, there is a large literature in urban economics trying to estimate this effect.[1] A problem that is commonly and increasingly recognized in this literature is the difficulty of determining the precise reason why people in dense agglomerations are more productive. Do productivity spillovers actually exist - that is, are there genuine economies of density in production - and if so, what is the efficient size of an agglomeration? Or, is it the case that location choice is endogenous and that, for some reason, agents that are more productive sort themselves into denser concentrations?

By building on the case of classical music, this article makes a useful contribution to this literature. It provides an investigation of the causal effect on productivity of being located in cities of various composer population sizes. The data used covers 116 prominent classical composers - a homogeneous group of creative individuals - born between 1750 and 1899. There are several reasons for the selection of this specific sample. First, in the period analyzed classical composers were independent artists with a remarkable entrepreneurial drive (Scherer, 2001).[2] They became market oriented and can be regarded as producers who supply cultural goods (new compositions) and provide certain services, such as teaching, organising tours, performing, etc. (Borowiecki, 2012). Second, the period encompasses many of the most influential composers, and hence data is relatively well available and reliable. Third, composers were highly mobile individuals and exhibited remarkable clustering patterns (O'Hagan and Borowiecki, 2010). Fourth, the employment of a unique instrumental variable becomes possible.

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[1] Rosenthal and Strange (2004) provide a substantial overview of this literature. Refer also to Törnqvist (2011) for a more recent overview of creativity in cities.

[2] In the analyzed time period, music lost its elitist image and was increasingly composed for the individual, as opposed to, for the court or elite. As a result, composers could find employment also as directors of private orchestras, as conservatory professors and private teachers or they could act as impresarios and organize their own performances.

The case of composers is also a very interesting one. On the one side, composers potentially benefit from interactions with their peers. On the other side, they also compete with fellow composers for access to limited facilities and finite resources within a city. At the turn of the 19th century, most European (or North American) cities had one concert hall with a domicile symphonic orchestra and one opera house with a local opera company. Even very large cities usually did not have more than one concert hall or one opera house. Furthermore, at those facilities only one composer could have had his works tested and performed at a given point in time. As a result, composers were exposed to a trade-off between agglomeration economies, which are associated with better peer interaction, and agglomeration diseconomies, which result from constrained access to production resources. The underlying study provides a theoretical setting which models the discussed trade-off and presents an empirical test.

Since location choice is endogenous, centrality of birth - that is, the average distance between a composer's place of birth and the birthplace of his peers - is used as an instrumental variable. The chosen methodology makes it credible to assert that the association between locating in an agglomeration and the individual's productivity is a causal relationship rather than simply a correlation. Furthermore, the employment of instrumental variables prevents any omitted variable bias which, for example, might result from unobserved qualities of the local cultural infrastructure. The geography of one's birthplace can be a significant factor in explaining location choice in historical time periods when traveling was difficult. For this reason, the investigation is conducted for the late 18th and 19th centuries when, due to technological inventions such as the railway or the steamboat, travelling was possible but still very expensive in terms of time and price. And therefore the geographic location of a person's birth mattered. Furthermore, the average distance between a person's birthplace and main urban agglomerations is arguably as good as randomly assigned: once a person is born, the birth location cannot be influenced anymore.[3]

Relative to the existing literature, the strengths of the data are detailed information on the individual's place of birth, location choices over his lifetime and annual production outcomes.[4] These unique features of the database have been first exploited by Borowiecki (2013a) who provides an analysis of the causal effects of locating in one of the three predominant locations for music (Paris, London or Vienna). Borowiecki finds causal

[3] One might be concerned that parental choices potentially drive the results. This issue is discussed in Section 3.1 and investigated in Appendix 2.

[4] The male form is used, as all covered composers are male.

productivity gains associated with locating in one of these three cities and shows further in placebo tests that these gains disappear in selective cities that had a small population of composers.

The underlying study extends and solidifies the previous knowledge in three dimensions. First, the study introduces a new theoretical framework that formalizes the trade-off between agglomeration economies, which are attributable to factors such as improved peer interaction, and agglomeration diseconomies, which could be related to restricted access to production factors. The underlying theory provides also insights why large cities remain stable over time, whereas small cities gain importance only over relatively short periods of time. Second, the investigation sheds light on the importance of location benefits depending directly on the size of artists' population, as opposed to the incidence of locating in one of the three main cities for music. This constitutes further support for the findings presented by Borowiecki (2013a) that the observed location benefits are attributable to the presence of peers and not some other, large city-specific determinants. Third, the hypothesis of the co-existence of agglomeration economies and diseconomies is tested by the employment of a new methodological setting which allows to illuminate non-linear effects. The approach enables further to investigate what size of a peer group leads to the greatest productivity gains, enabling so to answer the interesting question whether this efficiency is observable in the historical data.

Similar as in the context of explaining total population size of a city within urban economics, the model provides information on what is the stable city size in terms of composer population. In other words, it shows why some locations become important destinations only during a short period of time, whereas other, those that obtain a sufficient large composer population, remain important over a long period. This delivers tentative evidence as to why Paris has persisted as a major destination for music throughout a period of more than four centuries, while most other cities played a role only in relatively short time spans. This is in fact a central question regarding the geography of artistic activity within cultural economics, urban history and art history research in which it has often been wondered what constitutes the determinants of the remarkable dominance of Paris, both in terms of scale and duration (e.g. O'Hagan and Borowiecki, 2010, Hall, 2006).

The findings suggest a strong and positive causal relationship between the size of the agglomeration, measured in terms of the number of a composer's peers and his annual productivity. A composer was about ten per cent more productive when an additional prominent composer was located in the same city. I further find that the disclosed productivity gain is characterised by an inverted U-shaped relationship. The productivity gains from the presence of peers increase until the city size, measured in composers, is around 66 per cent above the average. From this size on, the gains decrease and eventually become negative for large cluster locations with more than 235 per cent composers above the average. These results are robust to a large series of tests, including checks for quality of peers, city characteristics and different measures of the productivity of composers.

The remainder of this article is organized as follows. In section 2, a theoretical framework for agglomeration effects is introduced. In section 3, the data is summarized. In section 4, empirical estimations are presented, and in section 5, concluding remarks are provided.

2. Theory

The mechanisms of agglomeration economies are categorized by Duranton and Puga (2004) into learning, matching and sharing.[5] Cities are expected to facilitate learning by bringing together a large number of people and enabling knowledge diffusion. The transmission of skills and ideas is arguably a very important driver for economic development and presumably a significant determinant for the emergence of agglomerations. Exchanging of ideas or commenting on each other work is potentially conducive to creative output and as such possibly a driver of productivity within the arts economy. In agglomerations it is also arguably easier to find the right match, be it a match to a sheet-music producer or an impresario.[6] The expected chances as well as the quality of such matches are arguably higher in larger agglomerations. Therefore, it could also be expected that an individual's productivity is greater in larger clusters due to the benefits arising from such matches.

Location specific benefits could stem from sharing of indivisible inputs. Consider the example of a concert hall. This is an expensive facility which involves high fixed cost: it needs to be of a specific size and shape to allow good resonance, have a symphonic orchestra etc. Furthermore, a concert hall is an indivisible facility, which cannot be subdivided but needs to be shared by a number of users. Obviously, few individuals, if any, would hold a

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[5] See also Florida (2002), Lloyd (2006) and Currid (2007) for qualitative discourses on clusters in the creative economy.

[6] While it is beyond the scope of this study, it should not be overlooked that composers have matched with people from other cultural disciplines, e.g. with writers or visual artists. Borowiecki (2013a, p. 96) provides some anecdotal evidence on the intensity of those relations. The worry of a bias due to the unobserved effects of other creative people, is somewhat mitigated later in the econometric analysis by inclusion of various controls (e.g. city fixed effects). Refer also to Karlsson (2011) for an elaborate discussion of network benefits associated with diverse geographic clusters.

concert hall for themselves. Holding such an infrastructure is only possible if there is a critical mass of composers – i.e. suppliers of new compositions. As such, some degree of clustering is required in order to enable the maintenance and functioning of such infrastructures. At the same time, a concert hall is a facility that cannot be built of an infinitely large size. Due to various technical and resonance-related concerns, even very populous cities, which might have a large mass of people wanting to attend concerts, would have concert halls of only a certain size, and not larger. It was also very uncommon to have two or more concert halls or opera houses in one city. It is fairly well documented that even very large and wealthy cities have had only one concert hall and only one opera house, usually built around the turn of the 18th century. As a result, the facility would be subject to increased crowding, and the capacity constraints would take two forms. First, there would be crowding when too many concert attendees (consumers) simultaneously tried to use the facility. Second, and of greater relevance to this study, there will be capacity constraints when too many composers simultaneously try to use the facility. In the case of such crowding, composers would encounter difficulties in performing and testing their work. As a result, their creative production might be delayed or hindered. Below, I suggest a theoretical framework which enables a better understanding of the consequences of artistic crowding.[7]

Cultural goods are produced using one variable production factor, *artists' labor*, which is initially assumed to be homogeneous. The composer's production function is

$$X = F(N),$$

where X is the amount of the cultural good and N is the mass of artists. This function is such that $F(0) = 0$, it is strictly increasing in N, and there exists $N_k > 0$ such that

$$\frac{\partial F}{\partial N} \frac{>}{<} \frac{\mathrm{F(N)}}{\mathrm{N}} \quad as\ N \frac{>}{<} N_k.$$

Thus, production involves increasing returns for $N < N_k$ and decreasing returns for $N > N_k$. The function is increasing as interaction among artists enables them to benefit from each other and be more productive. Those benefits are initially increasing exponentially to a point

[7] Even if we will not be able to disaggregate peer effects into benefits and costs in the applied analysis, the theory provides a useful tool in understanding the nature of the associated drivers. The theoretical foundation will also enable to link the empirical results with anecdotal evidence on the persistency of certain cities.

where the function turns and the perceived benefits from a large peer group are eventually decreasing, reflecting diminishing returns to scale.

However, crowding of artists is also associated with a cost. Let $C(N)$ denote the value of the crowding cost, measured in terms of cultural goods, evaluated for the allocation when the artists population is equal to N. In analogy to Fujita and Thisse (2002, proposition 4.1), who derive residential cost for a monocentric city, we assume these costs to be strictly increasing and strictly convex in N. The intuition behind this is that the cost associated with artistic crowding within the city increases more than proportionally with the population of artists, and as such there are diseconomies of urban agglomeration when the number of artists rises. This is a result of the previously argued limited access to relevant cultural infrastructure, which leads to increased waiting time of the composers for having works tested and performed.

From the artist's perspective, the optimum population of artists, which maximizes the level of cultural output Ω, is given by:

$$\Omega(N) = \gamma F(N) - C(N),$$

where γ denotes society's preference for cultural goods. In some cities cultural production might be appreciated more than in others, and as such it benefits the city and the composer more. Differentiating Ω with respect to N yields the following equilibrium condition:

$$\gamma \frac{\partial F(N^*)}{\partial N} = \frac{\partial C(N^*)}{\partial N}.$$

The second-order condition is defined as follows:

$$\gamma \frac{\partial F^2(N^*)}{\partial N^2} - \frac{\partial C^2(N^*)}{\partial N^2} < 0,$$

and thus both $\frac{\partial F(N^*)}{\partial N} > 0$ and $\frac{\partial F^2(N^*)}{\partial N^2} < 0$ are consistent with the second-order condition because $C(N)$ is strictly convex.

The solution to the optimization problem is presented in Figure 1. The production maximizing number of artists occurs at point N^* when the tangents to $\gamma \frac{\partial F(N^*)}{\partial N}$ and $C(N)$ are parallel.

[insert Figure 1 here]

This is the artist's optimization problem since her utility depends only on cultural production $U(\Omega)$. Prominence, sometimes immortal fame, can be reached only due to the production of Ω. Some artists might provide also cultural services, such as teaching, performing or writing. The success (and commission) of those other activities, however, depends on their production of Ω, since more productive artists are more sought after and are hence able to obtain better opportunities. Anecdotal evidence provides further support for the role of the artistic creation of composers, who usually kept composing until the end of their life, unless hindered by some serious illnesses. This is different when it comes to providing cultural services: most composers ceased teaching or performing when they retired. These individuals are regarded as 'prominent' nowadays because of their written compositions as opposed to other work they might have undertaken (e.g. teaching services).[8]

Greater creative production, however, benefits also the city. For several reasons, having cultural goods produced in a city creates positive externalities. First, locally produced cultural goods contribute to a city's cultural wealth, which is an important determinant of the perceived prestige of the city. Second, since the goods are locally produced, the residents' self-esteem and communal spirit is strengthened. Third, consumption of such goods enables the elite to differentiate themselves from the rest of the population. Fourth, offering cultural goods to the governed society increases their affinity towards the ruler of the city.

It has been assumed so far that artists are homogeneous. In reality, some artists might be more capable of exploiting peer effects than others and would thus inhabit different production functions, such that, for example, $F_i(N) > F_j(N)$. In order to incorporate artists' heterogeneous productivity levels, we treat the suggested production function (i.e. $F(N)$) as being representative of the average artist.

Note that implications stemming from this model would not change if some of the assumptions were lessened. For example, if trading of cultural products with outside the

[8] As economists we would like perhaps to see the overall income in the utility function of a composer. It is unfortunately out of scope to comprehensively measure the wages of artists, especially in historical periods. Since the end of the 18th century, however, composers predominantly made their living from publishers' fees, received from sales of written works (Albinsson, 2012). This implies that composers' earnings are correlated with creative production. Furthermore, while only indicative and selective, one might also often discover in the writings of composers that it was not the commission which was the driving force of their creative work. For example, in the words of Frederic Chopin, '*I'm a revolutionary, money means nothing to me*' (Hedley, 1947).

world was allowed, introducing a world competitive market price p into the production function (i.e. $p\gamma F(N)$) would shift the optimum artist population size to the right and lead to a higher production of cultural goods. Intuitively, cultural goods production would be higher in an open economy setting, because the artist had greater incentives to produce. The inverted U-shaped association between peer group size and the productivity of artists, however, would remain persistent.

Potential artists enjoy a reservation utility level, $\bar{U}$, in the rest of the economy. To be able to produce, the city must attract some artists from the rest of the world. To this end, artists' production must improve in the city to a greater extent than at the place they left behind. Given this production benefit, artists will migrate to a city as long as the utility level they can reach there is higher than or equal to their reservation utility.[9]

[insert Figure 2 here]

The efficient population of artists within a city is the consequence of a trade-off between agglomeration economies and crowding. The efficient city size increases with the extent of aggregate increasing returns and falls with crowding costs. As can be seen in Figure 2, cities of a given specialization are at the most characterized by two different sizes in the equilibrium, to the left and to the right of the efficient size. Cities with a population of artists below the efficient size are, however, are very fragile to changes in the distribution of workers. Those that see a rising number of artists will get closer to the efficient size and attract even more artists, while those that lose artists will get further away from the efficient size and lose even more artists. This is different for cities that are above the efficient size. Those that experience a decrease in the number of artists will get closer to the efficient size, while those that gain artists will get further away. As a result of these forces, cities of the same specialization are of equal size and too large.

3. Data

3.1 Identifying the composers

The underlying database covers important classical composers that are listed in Murray (2003). Murray's work is based on a wide range of international reference works, and

[9] It is disclosed later on that the equilibrium utility level in the city decreases when the population of artists rises. Consequently, artists will stop migrating just when the utility level they can reach within the city is equal to $\bar{U}$. Obviously, such a problem belongs to the family of open city models (compare to Fujita and Thisse, 2002).

therefore it is believed to contain a reliable selection of important creators, as any country-specific bias in sampling is supposedly marginal. Furthermore, based on the amount of space allocated to each composer in the reference works, Murray also provides an index score. The index score is thus a time-invariant measure of composers' lifetime accomplishments. It is normalized so that the lowest score is one, and the highest score is 100, which is achieved by two composers: Ludwig van Beethoven and Wolfgang Amadeus Mozart. In later specifications, the index will be used as a measure of composer's quality. Since it is a time-invariant variable it is suggested as a rough approximation of composer's skills.[10]

Background information on each composer is obtained from Grove Music Online (2009). The chosen dictionary is 'a critically organized repository of historically significant information' (Grove, 2009, preface) and is regarded as the leading source for music research. The biographical information provided for composers is detailed enough in order to track migration, especially work-related movements. The focus of this study is only on the periods of a composer's life when music-related work was predominant, i.e. when a composer was composing, giving tours, conducting philharmonics, teaching at music schools, managing music institutions or travelling in search of inspiration. As such, the analysis does not include the composer's infancy, retirement years and periods when only other (i.e. not music-related) professions were exercised. This is an important restriction, as it ensures that the individuals covered were indeed composers and are hence comparable. The migration patterns of a composer are recorded from the first year he becomes involved in a music-related activity other than learning, which would usually be the composition of the first work.[11] This is in order to avoid any potential endogeneity of the composer's decision to enter the labor market. While taking on the first occupation in the music profession might be endogeneous to locating in a city with many peers (or to the composer's productivity), it is much less likely that composition of the first work would be.[12] One might further worry that the composer's decision to leave the labor market and to retire might constitute another source of endogeneity bias. This, however, is a very unlikely case as retirement is hardly evident in the biographies of the individuals covered. Famous composers kept on with their creative work throughout their entire lives. Anecdotal indication on the role of music composition in a composer's life is depicted in the words of Sergei Rachmaninoff: '*Music is enough for a*

[10] For a meaningful econometric analysis it is however important to have a time-varying output measure. The next subsection 3.2 introduces and discusses a suitable variable. It is recognized that any reasonable output measure would be related to Murray's Index Score.
[11] The male form is used, as all composers covered in this research are male.
[12] Since the composers covered have often written their first meaningful composition already during their musical training, the sample includes their years in education.

lifetime, but a lifetime is not enough for music'. In a few cases, due to some major illness, a composer was forced to 'retire' earlier; however the incident of a serious illness is sufficiently exogenous.

3.2 Measuring creativity

Obtaining a reliable database for the output of historical composers is even more difficult. One possibility would be to work with data on the repertoires of leading symphonic orchestras or classical music albums. However, such an approach is fairly out of scope, primarily as comprehensive and consistent data for such a large sample of composers is not available. If one decided to follow this line nonetheless, it would not be possible to disaggregate the status of a historical composer from the standing of a contemporary performer. In addition, repertoires and especially recordings include numerous works, which have been composed by various artists. As a result, it would be impossible to identify the influence of a particular composition. For these reasons, the output data set is obtained in reliance on ratings made by experts. In particular, I use the 'The Dictionary of Composers and Their Music', written by two prominent musicologists - Gilder and Port (1978). The compendium is an acknowledged selection of the most influential classical works and has often been used to measure composers' productivity (e.g. Simonton, 1991). The dictionary contains, for a selection of 275 composers born between 1500 and 1949, a comprehensive list of their *important* works, including the date of composition. The authors of the dictionary aim to provide a dictionary 'of lasting value as a permanent reference (…) [that contains] (…) complete factual information about who wrote what, and when' (Gilder and Port, 1978, preface). There are several implicit advantages of relying only on important compositions. Primarily, those are the works that made a significant contribution to the classical music canon and as such are remembered beyond the life of a composer. The selection is therefore not biased by pieces of no lasting value, such as the jottings of composers, trifling pieces or tentative works. Furthermore, unfinished works are omitted. Since Gilder and Port (1978) also provide a brief description of the type of work, which makes it possible to categorize the compositions into one of the four categories: concert, chamber, opera or church works. Using sub-samples of the type of work will allow me to shed light on the robustness of the conducted estimations (see section 4.4).

3.3 Data Summary

This section provides summary statistics for the underlying sample of 116 prominent composers who are listed in Murray (2003) and whose works are selected by Gilder and Port (1978). Table 1 describes the data. The covered composers lived for 67 years on average and were involved in music-related work during 45 years. Musical education or training lasted on average nine years. Many composers were born into families with music traditions: in 55 per cent of cases at least one of the parents was involved in a music-related activity (e.g. father played piano) and 31 per cent had some other family member involved in music. Twelve percent of the composers were born in the second half of the 18th century, around one third in the first half of the 19th century and the remaining artists in the late 19th century. Germanic countries (i.e. Germany, Austria or Switzerland) and France accounted for the highest share of births of composers – above one-fifth each, followed by Italy and Russia with each roughly 12 per cent of composer births. The remaining births are spread across other – mostly European – countries. The quality score based on Murray's Index is equal to 12.7 points (on a 100 point scale). On average 0.77 compositions were written annually, which implies creation of around three works every four years. Concert works are the predominant type of works (0.42 works per annum), followed by chamber works (0.2), opera type of works (0.13) and church works (0.02). The centrality of birth of a composer - that is, the average distance from his birthplace to the birthplace of a fellow composer - is equal to 876.1 miles. The mean number of a composer's peer group size, that is, the number of fellow composers located in the same city in the same year, is 4.8 peers. The average quality of peers is calculated as the average Murray's Index Score of all composers located in a city in a given year and is equal to 10.1 points on average.

[insert Table 1 here]

Composers covered in this research have been working in a range of 26 mostly European cities. The distribution, however, has been heavily concentrated in only few of these locations. Table 2 provides a summary of the main cities and reports the number of composer-year observations as well as the average peer group size and quality. As one might expect, Paris is found to be the predominant location, with a composer's peer group size of around 11.6 composers. That is, a composer located in Paris had 11.6 peers on average. The French capital is followed in its importance by London and Vienna with peer group sizes of around 4.6 and 3.4, respectively. St. Petersburg has been a location with an equally large peer group size (around 4.3), however was important during a shorter period of time (only 336 annual composer observations are counted).[13] All remaining cities see a gradual decline in peer group size. The average quality of those peers is the highest in Vienna (a remarkable 27 points on Murray's Index Score). This is caused by the fact that Mozart, Beethoven and many other highest ranked composers worked in Vienna.

[insert Table 2 here]

Appendix 1 provides an illustrative overview of the available cultural infrastructure, in terms of opera houses and concert halls. It can be viewed that each of the cities covered had usually one opera house and one concert hall in the period studied.[14] Often opera or concert have been performed in temporary locations, e.g. national theaters, however once the specific infrastructure was constructed, the performances have been moved to the new facility.[15]

Figure 3 illustrates how a composer's peer group size changed over time. Since only individuals born after 1750 are covered, we observe a relatively small number of peers in the earlier years. The number of peers is increasing until the 1830s, from when it remains stable at around six peers until the beginning of World War II. At the end of the sample period, composers decentralize, which is partly attributable to the war. The number of covered composers is decreasing, which is, however, also due to the falling number of observations, since only artists born before 1899 are included.

[insert Figure 3 here]

Figure 4 shows how average peer quality changes over time. As one would expect, it takes the highest values around the turn of the 19th century, during the golden years of classical music. This is also a period for which relatively few observations are available, and hence peer quality is observed to be extremely high. From the second half of the 19th century, average peer quality stabilizes and fluctuates around nine points on Murray's Index Score until last observations.

[13] The relatively short spam of the importance of St. Petersburg is attributable to the move of the Russian capital to Moscow in 1918, when also Russia's cultural life has been shifted to the new capital.
[14] Note that in American cities, such as in New York, earliest opera performances were staged in the Italian Opera House which opened just in 1833. For these cities, however, we observe composers only in the later part of the period (e.g. the earliest observation for a composer working in New York is the year 1876).
[15] Refer to Falck et al. (2011) for a coherent overview of the development of baroque opera houses and the cultural politics in Germany from the 17th to 19th centuries.

[insert Figure 4 here]

4. Empirics

4.1 Estimating Peer Effects

I employ this data set, in order to establish the role of peer effects among composers. Interactions between composers are elusive. It is very rare for a work to be written in collaboration by multiple composers. There is, however, wide anecdotal evidence about composers commenting on each other's ideas and discussing their artistic output. Composers have often met in informal settings and '*discussed art, poetry, thought, music, drama, in fact all that constitutes life*' (p. 19, Brook, 1971). Furthermore, peers may have better contacts to influential members of the profession. It is also possible that competition was the driving force of a composer's productivity. Below, the total of all those peer effects are estimated.

The main objective of this analysis is to estimate the association between the productivity of composers and the number of peers located in a densely populated geographic space. For this reason, I regress an individual's productivity on the number of his peers located in the same city in the same year. The productivity of composers is arguably not only affected by the number of peers they can interact with but also by the average quality of peers. As cities differ substantially in size and quality, it is important to distinguish these two dimensions of peer effects among composers. I therefore propose the following regression:

$$Composition_{it} = \beta_0 + \beta_1\ PeerGroupSize_{it} + \beta_2\ PeerQuality_{it} + \beta_3 AgeCohortFE_{it} + \beta_4 DecadeFE_{it} + \varepsilon_{it} \qquad (4.1)$$

The number of compositions written by composer *i* in year *t* is regressed on measures of his peer group and other controls. The number of peers is obtained by counting all fellow composers located in the city where composer *i* is located in a given year.[16] Peer quality is calculated as the mean Murray Index Score of a composer's peers. Over time, changes in average peer quality occur only if the make-up of the group of composers changes, that is, if a peer leaves the city or a new one arrives. Yearly fluctuations in productivity outcomes of the same set of peers do therefore not affect peer quality. The underlying assumption is that

[16] Some composers visited more than one location in a given year. For those incidences, the average number of peers is calculated. We will later see that dropping these observations does not alter the results.

Ludwig van Beethoven always had the same effect on his peers, independent of how much he composed in a given year.[17]

The regression also contains a full set of 5-year age cohort dummies to control for life cycle changes in productivity. Decade fixed effects control for decadal variation in productivity levels that affect all composers in the same way. In the previously introduced theoretical model, all agents have been assumed to be identical. This is not true in general. Therefore, in some specifications, to control for unobserved differences between composers, such as their ability, I include individual fixed effects. Some robustness tests also contain city fixed effects to control for unobservable city-specific factors affecting a composer's productivity. Finally, the model contains a constant (β_0) and a standard variance estimator (ε_{it}).[18]

As a starting point of the empirical analysis, I estimate the relationship between a composer's production and his peer group characteristics (i.e. size and quality), using ordinary least squares. Table 3 reports the coefficients. Column 1 shows the baseline specification that contains decadal and age cohort fixed effects. Coefficients on both peer group size and quality are positive and significant. Ten additional composers located in the same city are associated with a higher productivity of a composer by around 0.47 works per annum. In cities with average quality of peers higher by ten points (on Murray's Index Score) a composer creates 0.35 works more. In column 2 it can been viewed that these correlation coefficients are robust to the inclusion of a full set of composer fixed effects. Column 3 reports a regression with a set of city fixed effects. Both coefficients on the number and quality of peers are significant and imply that composers located in cities with more or better peers are more productive.

[insert Table 3 here]

It is also interesting to look at the relationship between changes in peer group characteristics and changes in productivity outcomes. Column 4 reports a model where first differences in the dependent variable as well as explanatory variables of main interest are

[17] An alternative way of measuring average peer quality uses average annual productivity of a composer's peers. Such specification allows for peer effects to vary over time and to account for current productivity levels of a composer's peers. Using this measure does not affect the presented findings.

[18] In a range of robustness specifications, the standard errors have been clustered, for example at the composer (or city) level, allowing for correlations between observations within a single composer (or city), but remaining independent between composers (or cities). The results remain consistent with a marginal decrease in significance (not reported).

included. It can be seen that both coefficients are positive and significant, suggesting that an increase in peer group size or quality is associated with a higher level of productivity of a composer. Furthermore, both coefficients are now even more comparable in size, providing some indication of a similar role of each of the peer measures. Composers located in cities that had a faster growing population of composers or that better peers arrived to, are associated with higher productivity growth. The model is extended to include composer fixed effects in column 5 and additional city fixed effects in column 6. The results remain consistent.

Music compositions are count data with a relatively large proportion of zeros and take only positive values. Instead of OLS, it might therefore be preferable to use a model that specifically addresses the nature of the underlying data. Table A1 in the appendix reports Poisson regressions for the association between a composer's creative production and peer group size. The results are consistent. In fact, now the point estimates on the quadratic peer group size polynomial are estimated with even greater precision and support the posited heavy curvature of the productivity function.[19]

Those associations could be either a consequence of locating in cities with more and better fellow composers (i.e. peer effects) or are attributable to self-selection of better composers to such locations. Therefore, it is important to employ a methodology that makes it possible to establish the causal effect. Such approach would also relate to the previously introduced theoretical model which shows how productivity *gains* depend on the number of peers. For this reason, an instrumental variable identification strategy is developed and applied in the next section, in order to endogenize the peer group size variable.

4.2 Instrumenting for peer group size

The previously employed models to estimate equation (4.1) might lead to biased coefficients of β_1, and there are three reasons why this could be the case. First, the results might be biased due to selection issues. It is likely that composers chose their work location based on their ability: more talented composers might have self-selected into cities where more peers were located. A further source of bias is caused by omitted variables. Unobserved variables, such as the quality of cultural infrastructure of a city, may drive both clustering intensity and creative production. Furthermore, the number of peers located in the same city is only a

[19] The baseline specifications are estimated using OLS in order to enable a comparison with a two-stage least squares estimator, which will be employed in the later part of the paper. Two-stage least squares is typically the most efficient instrumental variable estimator and should be preferred even in the case when the endogenous variable is dichotomous (see, for example, Wooldridge, 2002).

tentative indicator of the interaction that has taken place with those peers. Interaction might also have occurred with any other non-prominent composers who were not famous enough to be included in the source dictionary and are hence unobserved in this research. To address these issues, instrumental variables are used.

I propose a measure of geographic centrality of a composer's birthplace as an instrument for the size of the peer group of composers. The centrality of birth variable is calculated for each composer as the average geographic distance between his place of birth and the birthplace of a fellow composer.[20] It is expected that composers born closer to the birthplace of their peers were more likely to experience a larger number of peers during their working life. The birthplace-cluster distance is captured as a logarithm in order to allow for decreasing importance of large distances for composers born in remoteness. Peer group size is identified as follows:

$$PeerGroupSize_{it} = \gamma_0 + \gamma_1\ BirthCentrality_i + \gamma_3 AgeCohortFE_{it} + \gamma_4 DecadeFE_{it}\ + \mu_{it} \qquad (4.2)$$

For the instrumental variable to be valid, it is required that the exclusion restriction holds. A composer's production must depend on peer group size, and the centrality-of-birth measure impacts the composer's output only through its impact on the number of peers. Technically, the instrument must not be correlated with the error term in the equation (4.1), that is $Cov(\varepsilon_{it}, BirthCentrality_i) = 0$. It is possible that a composer who does not locate directly in a city with a large peer group but in its surrounding area, might profit from the vicinity to his peers or music relevant facilities and infrastructure. To prevent this kind of proximity effect, I treat all locations within a radius of 50 miles from each city as the city itself. It is a radius within which it is likely that a person has reasonable access to his peers or the city's music facilities.[21] Furthermore, it has to be noted that the average distance between a composer's place of birth and the birthplace of a peer has been on average 876 miles and hence very large. It is unlikely that any benefits (be it interaction with peers, access to music venues, printing facilities or music conservatories) are experienced on such large distance, especially in the analyzed historical period. And yet, as we will see, being born closer to the

[20] Formally, centrality of birth is calculated as follows: BirthCentrality$_i$ = $\frac{1}{115}\sum_j^{115}$ distance $_{birhplace_i\, birhplace_j}$.
[21] The size of the radius was previously used by O'Hagan and Borowiecki (2010). It was only in a few cases necessary to readjust the locations. For example, Sir Arnold Bax was born in 1883 in Streatham, less than 10 miles from the city center of London. Nowadays, Streatham is a district of South London.

birthplace of fellow composers has increased the probability of experiencing a greater peer group size later in life.

In particular, one might worry that composer births have been more likely to occur in or around important cities for music, where a person might have obtained better music education. While information on the quality of a person's education is unattainable, it is fairly well recorded in the source dictionary how many years a composer has been studying music, be it in the form of private tuition or formal studies at conservatoires. Using this information, a range of tests has been conducted and I found no systematic difference in the duration of music education times depending on a composer's place of birth or number of works composed. One of these attempts is presented in column 3 of Table 7 and discussed further in section 4.4 (see also Marrocu and Paci, 2012, for an interesting discussion on the association between education and creativity). Next, it is required that the instrument is as good as randomly assigned. A composer cannot change his place of birth once he is born and births are spread fairly uniformly over geographic space. In addition, parental choice over their child's location of birth in a wide trans-European context is reasonably constrained, in particular when geographic mobility was costly. It is nonetheless possible that certain families that, for example, value strongly musical education decide to settle in proximity to a musical hubs, and offspring of these families may have had better musical skills or better access to a relevant professional network. This might lead to an association between the peer group exposure and the unobserved drivers of output (i.e. ε_{it} in model 4.1). If this was the case, the randomness assumption would suffer. For this reason, I obtain from the Grove dictionary data on musical background of family members and provide an analysis of the outlined issue in Appendix 2. The findings from these robustness tests imply that a composer's birth location was indeed fairly independent from the influence of family, which provides support for the validity of the identification strategy.

Finally, the endogeneous variable must exhibit in the first-stage a statistically significant relationship with the instrument and its variation needs to be sufficiently well explained by the model. For this reason, using OLS, I investigate the association between a composer's centrality of birth and the number of peers located in the same city. The coefficients obtained on the role of centrality of birth are presented in columns 1 to 5 of Table 4. Column 1 presents the first-stage relationship between the average distance from a composer's birthplace to the birthplace of a fellow composer and peer group size. The model contains a set of controls for age cohort effects and time effects. The coefficient on the centrality of birth measure is determined precisely at a confidence level of 99 per cent. The term is negative and economically meaningful: composers born one per cent further away from the birthplace of peers typically experience a peer group size that is smaller by 1.6 composers. The goodness of fit statistic suggests that 19 per cent of the variability in the outcome variable is explained by the model.[22]

[insert Table 4 here]

Using a time-invariant instrument is useful to estimate the effect of *average* peer exposure, *ceteris paribus*. Our estimations are therefore meaningful as long as a composer's probability of being exposed to a given number of peers in a given year depends on centrality of birth *equally* throughout his entire life. However, this is not necessary always the case, as the size of the peer group at any point in time was possibly related to unobserved variables. Suppose, for example, that peer exposure over a person's life depends on unobserved skill and that there exist heterogeneous returns from peer interactions. Therefore, one might prefer to use a time-varying instrumental variable instead. It is unfortunately rather difficult to find a valid time-varying instrumental variable in the pursued historical setting. I use thus an interaction term between the centrality of birth measure and age. Such variable is time-varying, and therefore suitable as a measure of peer group size that can change over time.[23] A model using this instrument is reported in column 2 of Table 4. Since the instrumental variable is now changing over time, the inclusion of composer fixed effects becomes possible. Column 3 presents the results for a specification with a strong set of controls for unobserved differences between composers. It is encouraging that the results remain consistent - the coefficient fluctuates only to small extent - even if these powerful individual controls are introduced.[24]

In order to investigate the presence of a non-linear impact of the number of peers (measured with a quadratic peer group size polynomial), two instruments are required. For this reason, both of the previously introduced instrumental variables are employed in two

[22] Without inclusion of any control variables, the centrality of birth variable explains 8.5 per cent of the variation in peer group size. The coefficient on centrality of birth in a specification without any control variables would remain stable at -2.058 (*p*-value below 0.01).

[23] While the undertaken approach is potentially risky as it puts pressure on the validity of the exclusion restriction, as we will see later, the emerging results are rather similar independent whether time-invariant or time-varying instrumental variables are employed. Using the later however allows the execution of a range of additional estimations and tests.

[24] Another way to obtain a time-varying instrument is to calculate the centrality of birth as the average distance to the main three cities Paris, Vienna and London *weighted* by the number of composers located in each of these cities in a given year. Such an instrumental variable varies over time since the composer population in these cities was fluctuating. The further presented results would remain consistent (not reported).

estimations in order to model peer group size at level and peer group size squared. The results are reported in columns 4 and 5. It can be observed that significant associations arise with at least one of the instrumental variables.[25]As hypothesized, composers born further away from the birthplace of peers are typically less probable to experience the presence of many fellow composers. Geographic birth location is found to be a significant factor in determining a composer's peer group size. The negative relationship between centrality of birth and lifetime average peer group size is visualized in Figure A1 in the Appendix. The figure shows that the geographic spread of the birth place distances is fairly evenly distributed across all composers and that the estimated relationship is not driven by any extreme cases.

Using the centrality of birth measure to provide exogenous variation in an empirical model allows me to explicitly estimate localized peer group size effects. Using the first-stage estimations, as previously presented in Table 4, I endogenize the peer group size variable. Table 5 presents the results. Column 1 reports a specification where I use the centrality of birth as instrumental variable. The IV parameter is found to be positive and highly significant. The size implies that with each additional peer located in the same city, the productivity of composers increases by around 0.08 works per annum. Since the average annual productivity is 0.77 works, the result implies an economically significant increase of around ten per cent. Next, I use a time-varying instrumental variable (i.e. centrality of birth interacted with age) and report the results in column 2. While the IV coefficient remains positive and significant, it increases in size and implies a somewhat greater effect of peer group size. Since a time-varying instrument has been used, the model can now be extended by inclusion of composer fixed effects. In column 3 it can be viewed that the IV estimate increases further in size, while remaining consistent in sign and significance.

In these models we observe that the IV coefficient increases from 0.08 up to 0.34, which given the average annual productivity of 0.77 works might seem at first implausibly large. It is however important to note that the average peer group size at 4.82 is rather very small. Therefore, while considering the effect of the usual "one unit increase" in the explanatory variable, one must keep in mind that it is actually a rise of more than 20 per cent. Intuitively it makes more sense to interpret the effects as a percentage change of the mean. The estimated coefficient would suggest then that a one per cent higher peer group size leads

[25] Table 3 reports also the obtained Cragg-Donald EV statistic - a metric that indicates weak instruments. These are found to be always above the critical value of 7.03, as suggested by Stock and Jogo (2005) for specifications with two endogenous variables and two instruments. This implies that there is little worry for the instruments to be weak.

to a productivity increase of up to 2.5 per cent; an effect which is plausible and yet of rather large economic significance.

Finally, I employ a quadratic peer group size polynomial in order to study the presence of decreasing returns to size. For this reason, a regression is estimated using the following two instruments: centrality of birth variable interacted with age and without such interaction (first-stage estimates have been presented in columns 4 and 5 of Table 4). As can be seen in column 4, the IV parameters on both peer group size variables are estimated with large precision. While the coefficient at level implies a strong causal benefit from increasing peer group size, the quadratic term suggests that this occurs at a decreasing rate. Since one of the instrumental variables is constant throughout composer's life, including composer fixed effects is not possible. In section 4.3 however, a further time-varying instrumental variable is introduced, which will make it possible to account for composer fixed effects. At this stage, however, the introduction of city fixed effects is possible. Column 5 shows such a specification. The result implies that the estimation is robust to the inclusion of city fixed effects.

[insert Table 5 here]

Based on the calculated point estimates on peer group size, presented in column 4 of Table 5, I visualize the results in Figure 5. The vertical axis measures the number of compositions written per year as a result of peer group size. Since it has been instrumented for the number of composers, the productivity measure is causally attributable to peer group size. The disclosed peer benefit increases fairly linearly until a peer group size of 8.1 composers - that is, 166 per cent of the average number of composers in a city (i.e. 4.8). The curvature, however, is heavy and for cities with a higher number of composers the gains begin to decrease, but remain positive until 16.4 composers, which is 335 per cent of the average peer group size. It is interesting to observe that locating in cities with a larger peer group can be detrimental to a person's productivity.

[insert Figure 5 here]

Following the previously presented theoretical considerations, cities of a given specialization should be of two sizes in equilibrium. Cities should be either large and stable or small and unstable. Anecdotal evidence suggests this to be the case for cities specializing in music in the period studied. Consider Paris, where on average 11.6 composers were located and the two cities that follow the French metropolis in its importance, Vienna and London, where on average roughly four composers were located (Table 2). As can be seen in Figure 5, all three cities deliver approximately the same productivity gain of about 1.1 compositions, and possibly therefore, have not changed much with regard to composer population in the time period studied. This result is also consistent with Borowiecki (2013a) who studies clustering benefits for composers located in these three cities and finds comparable estimates. From a long-term perspective, however, Paris with its large composer population, has been the only 'stable' city and has been of marked importance for music throughout an astonishingly long period, from the 17th century until and including the 20th century (Borowiecki and O'Hagan, 2012), whereas Vienna and London played a role only during relatively short periods of time. Vienna, for example, was a meaningful destination at the turn of the 19th century, however, retained relatively little importance in other periods.

4.3 Instrumenting for peer quality

So far, the validity of an instrumental variable for peer group size has been established, and the causal effect of the number of peers on productivity has been studied. It is, however, also possible that the quality of the peer group matters for productivity outcomes of a composer. If peer group quality was not affected by the centrality of birth, this would not be a problem: one would still be able to estimate reliably the causal impact of peer group size on output. In other words, if truly exogeneous instrumental variables are used, the problem of omitted variables is mitigated. It is, however, possible that more centrally born composers have been exposed to better peers. In such a case, the endogenized peer group size variable would be biased: it would measure not only the productivity gains due to the number of peers, but also due to their quality. As such the peer size effect would be upward biased and the estimates would constitute the upper limit. In Appendix 3, three possibilities are explored in order to address this concern. It is acknowledged that the underlying task - to reliably account of peer group quality - is extremely difficult to achieve given the nature of the data and time period. The results indicate nonetheless a robust causal effect of peer group size and a somewhat less precisely estimated (albeit significant) causal effect of peer group quality on output. These results support also the existence of an inverted U-shaped association between number of peers and productivity gains.

4.4 Robustness

This section describes a range of tests that suggest that the results are robust. All conducted tests are presented for a basic specification with peer group size as the only measure of a composer's peer characteristics and use centrality of birth as the only instrument. The further presented and discussed robustness checks would, however, also remain consistent for specifications with a time-varying instrumental variable (i.e. birth centrality interacted with age) for models with quadratic peer group size polynomials as well as for estimations that account for peer quality.

The database used provides further records on the individual level. This information is used next as control variables in addition to the previously included age cohort and decade fixed effects. First, I include two indicator functions controlling whether one of the parents or any other family member of the composer was involved in a music related activity. Since the data source, Grove Music Dictionary, only accounts for music-related engagements of family members if they are of considerable quality and importance, the variable serves as an approximation of musical ability or networks. The results are presented in column 2 of Table 7 (column 1 reports the baseline specification). The point estimate on peer group size remains unaffected.[26]

[insert Table 7 here]

Composers' personal music-relevant networks might have benefited during their music education. It could thus be the case that peer group effects vary according to music-related education time. I therefore include an additional control for the duration of music education of a composer, as has been recorded in Grove (2009). It can be seen in column 3 that the IV parameter does not change.[27] It is encouraging that the results are robust to the inclusion of these powerful individual controls (family musical background and duration of musical education).

One might want to include a more precise control for unobserved time variation. Decadal fixed effects might not pick up some of the annual changes that influence productivity in a given year. For this reason, I estimate a model that includes a large set of 217 dummy variables that take the value one for each year (and remain at zero otherwise). The model with year fixed effects is presented in column 4. It can be seen that the coefficient

[26] The estimated coefficients on parental musical background is equal to 0.14 (*p*-value below 0.01), and on any other family members' musical background it is equal to 0.09 (*p*-value equal to 0.03).
[27] The estimated coefficients on music related education time is equal to 0.01 (*p*-value equal to 0.01).

of interest remains very stable.

All reported specifications contain 5-year age cohort fixed effects, which are strong individual controls. One might, however, wonder how the results differ for composers depending on their age. Therefore, I estimate two additional specifications, one for a sub-sample of composers below the age of 50 (young composers) and one for composers aged 50 or above (established composers). The results are summarized in columns 5 and 6. It can be observed that both coefficients remain positive and very significant, which supports the previously argued peer effects. It is, however, also very interesting to observe the difference in the size of those coefficients. The coefficient for the younger cohort is significantly larger than for the older cohort. This implies that a young composer benefited more from the presence of peers than an established artist. It is quite likely that peer interactions became less important once one had established a music career. This finding seems to be consistent with Waldinger (2010) who found that while doctoral students in science benefit from peer effects, more established researchers do not experience such effects.

It could be pointed out that some visits of a composer to a city were so brief that peer interaction was not possible due to time constraints. Therefore, in an additional estimation, observations in which composers remained in a location for less than one year are omitted.[28] The results are reported in column 1 of Table A7 and imply consistency of the main findings.

Due to a general migration tendency towards cities with a large peer group size, markedly more composers died in hubs for music than had been born there. The death year of each artist was not a full year of creative work, unless the death occurred on the last day of December, which is unlikely. I thus estimate a specification from which the death year is dropped. As can be seen in column 2 of Table A7, the coefficient on peer group size increases slightly, remaining, however, very stable.

Some composers visited several locations in a single year. For these observations the peer group size variable measures the arithmetic mean of the number of peers located in the cities visited. As a result, the established peer effect could be biased due to uneven time spent at each of the locations visited. This concern is analyzed by estimating a model where observations for years in which a composer has visited more than one location within one year are dropped. The IV results, as reported in column 3, indicate that the results are consistent.

The incidence of war has been arguably a significant determinant affecting music

[28] Note that while Grove (2009) includes very detailed information on composers' travels, the data is very often available only on an annual basis.

composers' migration and geographic clustering patterns (Borowiecki, 2012, 2013b) as well as their productivity (Borowiecki and O'Hagan, 2013). In addition, it is possible that some other distress factors such as an epidemic outbreak might have impacted their geography of work or production. Those exogenous shocks might not be adequately captured in our model, even with inclusion of year fixed effects. I therefore identify wars and epidemics that occurred in the studied countries and exclude those in a robustness specification.[29] Again, the estimation suggests a stable coefficient on peer effects (column 4).

It has been previously shown in Figures 3 and 4 that the total number of composers, peer group size and peer quality varied strongly over the time period analyzed. One could worry that the inclusion of decadal fixed effects does not deal sufficiently with such large variations. To deal with this concern, I therefore drop observations or periods with extreme values in several specifications.

Since the analysis is based only on composers born within a specific time period, it takes several years until we observe the presence of any peers for the earliest born. The early born composers were possibly located in cities where also other peers were located; however, since only composers born after 1750 are covered, their peers who were born earlier are not observed. A similar problem arises for composers born very late, who often outlived their peers that we observe. I drop therefore a large number of annual observations for which the database covers less than 30 composers. It is a very demanding test as we lose around 40 per cent of the observations. However, the results, which are presented in column 5 of Table A7 in the appendix, remain consistent.

A related concern is that due to the constrained observation window, in the early and late years there is observed only a limited number of composers and as a result the calculated peer group size is smaller than it was in reality. For this reason I drop all observations where composers have been located in cities with two or less peers. As such, to some extent this test also deals with the issue of remote or unique locations which are dropped in this estimation. Column 6 of Table A7 estimates peer effects within cities where at least three composers were located. The coefficient of interest is once again stable.

Another way to address the small peer group size (and number of observations) in early and late periods is to drop those observations. I therefore exclude all years before 1831

[29] I drop the annual observations in which any of the following conflicts or epidemics occurred: the French Revolution (1789-99), Napoleonic Wars (1799-1815), the cholera outbreak in 1832 and 1849, the war on Prussia (1870-71) and both World Wars (1914-18 and 1939-44). I also find consistent results after excluding only single observations for composers who were located in a given year in a country involved in those exogenous disturbances. Only the results for the stronger test are reported.

and after 1936. The selected cut-off points are the years when composers' average peer group size increased to above four peers (see Figure 3). Column 7 of Table A7 reports the coefficient of interest, which declines somewhat but remains positive and statistically significant.

There was also some variation in the quality of composers' peers. The turn of the 1800s is regarded as the golden age of classical music and coincides with the births of some of the most influential artists of all times. The average quality falls towards the end of the period studied for which more observations are available and any extreme values are balanced out. However, in order to deal with the peak in peer quality during the late 18th century I drop all observations where the average quality exceeds 30 points on Murray's Index Score.[30] The restricted specification is presented in column 8 of Table A7 and implies that the results are not driven by any extreme values of peer quality.

Appendix 4 presents a more elaborate test in which productivity benefits are estimated separately for several types of work (i.e. concert, chamber, opera and church works). This is motivated by the fact that the requirements for production facilities might differ across various types of compositions. The results from these estimations imply that the main findings are robust.

Finally, Appendix 5 discusses the issue of large city effects and shows that the results are robust to the inclusion of additional controls for overall population size of a city, as well as if one drops any of the three main geographic clusters.

6. Conclusion

This article provides an investigation of peer effects within music. Building on historical data on composers, I use a measure of a composer's centrality of birth as exogenous variation in peer group size. This allows me to estimate the causal impact of the number of peers on a composer's creative production in a given year. The findings imply that composers have in general benefited from peer effects. The associated peer benefits, however, are found to be decreasing with peer group size and eventually become negative for composers located in cities with a very large population of composers. These results are robust to various specifications accounting for peer quality and different types of works. They are likewise

[30] Alternatively, one might want to drop the two composers who have obtained by a margin the highest Murray's Indexes (Ludwig van Beethoven and Wolfgang Amadeus Mozart). The results would remain consistent. I report only the stronger test.

robust across many different estimations in which also time-varying birth centrality measures have been used as instrumental variables.

The problem of inefficient city size is predominant in urban economics literature. The efficient city size is the consequence of a trade-off between urban agglomeration economies and urban crowding. Cities are too large, which is a result of a coordination failure with respect to city creation (Duranton and Puga, 2004). The emerging results from the underlying study suggest that this was a likely case within the field of classical music. Paris was possibly too large in its composer population and, due to the inverted U-shaped association between productivity gains and peer group size, its size was inefficient. In other words, an individual composer would have benefited more in terms of written compositions, if Paris had a smaller population of composers. At the same time, the French capital was the only city with a sufficiently large composer population to persist throughout a remarkably long period of around four centuries. As such, this research provides an important contribution to cultural economics and economic history research, in which it has often been questioned why Paris was such an important destination for creative people in terms of size as well as duration (e.g. Hall, 2006). This analysis also contributes to the cultural economics literature by disclosing the presence of large peer effects among the studied sample of creative people. Studies on the historical role of agglomeration economies on creative outcomes include Boucekkine et al. (2007), who argue that high population density explains a large share of literary achievements of a society. Furthermore, this investigation puts the importance of centrality into a new dimension and supports the view that centrality impacts various aspects of creativity (see also Lorenzen and Andersen, 2009).

Recent research on peer effects in science seems to suggest that localized spillovers are of no significant importance (e.g. Waldinger, 2012, Azoulay et al. 2010). However, intellectual exchange between scientists differs from personal contact that takes place within creative disciplines where face-to-face interaction is perhaps of much greater importance (e.g. Currid, 2007a). Scientific interaction was already in the 20th century relatively easy due to the possibilities of exchange of ideas and work via correspondence and academic journals. This was later further facilitated by the availability of electronic mail. Such interaction was much more difficult, and possibly still is, in the case of creative people. Classical composers, for example, most likely require to listen to the work of a colleague in order to be able to comment on or learn from it.

An important question is whether historical evidence on peer effects among composers improves our understanding of peer interactions nowadays. It is fairly well established that certain creative disciplines operate in a similar way today. Perhaps the most important author to consider is Currid (2007a, 2007b, 2009) who examines the value of proximity and face-to-face interaction in the art, fashion, and music worlds of New York City. Also of interest is Rantisi's (2002) work on New York City's fashion industry, Storper and Venables (2004) insights on the value of "buzz" generated by face-to-face contact, and Lloyd's (2006) and Florida's (2002) analyses of creative milieus and their roles in the urban economy. Creative people require personal interaction in order to exchange their intangible ideas and to learn. Be it visual artists, contemporary musicians, or even entrepreneurs, face-to-face contact and observation of other persons' behavior or creative production (processes) might constitute important sources of productivity increases.

Finally, the observed agglomeration diseconomies, caused by higher crowding and waiting time, might be present in some non-music related contemporary settings. A similar problem is encountered in disciplines or industries that are characterized by constrained access to relevant facilities or resources. For example, in the short-run, when capital is fixed and the only adjustments are made to the number of hired workers, a firm faces an inverted U-shaped function between the value of the marginal product of a worker and the number of workers. A similar situation can possibly be observed in a real estate economy with restricted zoning or some other geographic constraints. If expansion is not possible, the optimum level of economic activity will be characterized by an inverted U-shaped function.

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Tables

Table 1. Summary statistics for 116 prominent composers

	Mean	Std. Dev.
	A: Background information	
Life span (in years)	66.85	15.07
Duration of Career (in years)	44.94	14.31
Education or training time (in years)	8.90	5.38
Music-related engagement of parents	0.55	0.49
Music-related engagement of any other family member	0.31	0.46
Average distance between composer's own birthplace and the birthplace of his peers	876.06	1094.49
	B: Birth cohort	
Birth cohort 1750-1799	0.12	0.33
Birth cohort 1800-1849	0.33	0.47
Birth cohort 1850-1899	0.55	0.50
	C: Birth country	
British Isles	0.08	0.27
France	0.22	0.42
Germanic countries	0.23	0.42
Italy	0.13	0.34
Russia	0.12	0.33
Spain	0.03	0.16
Eastern Europe	0.09	0.28
Rest of Europe	0.03	0.18
Rest of World	0.06	0.13
	D: Quality measures	
Murray's Index Score	12.67	17.16
Output (= Concert + Chamber + Opera + Church)	0.77	1.35
Concert works	0.42	0.86
Chamber works	0.20	0.71
Opera works	0.13	0.37
Church works	0.02	0.14
	E: Peer characteristics	
Peer group size	4.82	4.15
Peer quality	10.12	10.92

Sources: Data on composers are obtained from Grove Music Online (2009) and their works from Gilder and Port (1978).

Note: The British Isles include composers from England, Scotland, Ireland and Wales. Eastern Europe relates to composers born in any of the Eastern European countries as classified by the United Nations Statistical Division, with the exclusion of Russia. The Germanic countries relate to the three German-speaking countries of Germany, Austria and Switzerland. Rest of Europe covers composers from all other European countries. Rest of World relates to composers that do not fit in any of the other categories. Output is the number of important works written in a given year.

Table 2. Summary statistics for main cities covered

	Composer-year observations	PeerGroupSize		PeerQuality	
		Mean	Std. Dev.	Mean	Std. Dev.
Paris	1554	11.56	3.92	9.60	3.49
London	407	4.57	4.00	6.37	6.02
Vienna	344	3.42	2.79	27.38	24.47
St. Petersburg	336	4.35	2.74	6.73	2.83
Berlin	191	3.34	2.38	10.71	8.12
Moscow	148	2.38	3.45	5.52	5.50
New York	139	3.01	3.37	7.41	6.43
Rome	134	2.75	2.22	7.81	11.56
Budapest	110	2.45	2.66	8.59	4.19
Milan	105	2.50	3.18	16.72	10.55
Venice	91	1.99	3.32	6.67	6.02
Copenhagen	85	1.12	0.32	3.19	1.03
Boston	81	2.37	3.01	5.30	5.42
Prague	41	2.46	4.25	11.08	7.58
Leipzig	35	1.26	0.44	22.53	15.84

Note: ‘PeerGroupSize’ measures the number of a composer’s peers present in the city in a given year. ‘PeerQuality’ measures the average Murray’s Index Score of a composer’s peers located in a city in a given year.

Table 3. Peer group characteristics and production

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
Dependent variable:	Composition	Composition	Composition	D.Composition	D.Composition	D.Composition
PeerGroupSize	0.0472***	0.0291***	0.0396***			
	(0.00892)	(0.00846)	(0.0117)			
PeerQuality	0.0354***	0.0107***	0.00946***			
	(0.00193)	(0.00202)	(0.00214)			
D.PeerGroupSize				0.0238***	0.0244***	0.0197**
				(0.00795)	(0.00819)	(0.00860)
D.PeerQuality				0.0206***	0.0207***	0.0213***
				(0.00272)	(0.00279)	(0.00282)
Decade FE	yes	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes	yes
Composer FE		yes	yes		yes	yes
City FE			yes			yes
Observations	4,963	4,963	4,963	4,751	4,751	4,751
R-squared	0.180	0.453	0.456	0.016	0.018	0.019

Note: Standard errors are reported in parentheses. The dependent variable, 'Compositions' measures the number of important works written by a composer in a given year. 'PeerGroupSize' counts the number of a composer's peers present in the city in a given year. 'PeerQuality' is measured as the mean of the average Murray's Index Score of a composer's peers present in the city in a given year. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table 4. First-stage regressions for peer group size

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
Dependent variable:	PeerGroupSize	PeerGroupSize	PeerGroupSize	PeerGroupSize	(PeerGroupSize)^2
BirthCentrality	-1.614***			-1.565***	-25.93***
	(0.0994)			(0.134)	(2.120)
BirthCentrality * Age		-0.0152***	-0.00922***	-0.000990	0.0634**
		(0.00136)	(0.00213)	(0.00181)	(0.0286)
Decade FE	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes
Composer FE			yes		
Observations	4,963	4,963	4,963	4,963	4,963
R-squared	0.190	0.168	0.707	0.190	0.161
F-statistic	263.8	124.9	18.8		
Cragg-Donald EV Stat.				38.4	38.4

Note: Standard errors are reported in parentheses. 'PeerGroupSize' counts the number of a composer's peers present in the city in a given year. 'BirthCentrality' is measured as the mean distance between a composer's birthplace and the birthplace of his peers. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table 5. Instrumental variables (Peer group size effects)

Dependent variable: Composition

	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV
PeerGroupSize	0.0775***	0.166***	0.342***	0.527***	0.378*
	(0.0166)	(0.0271)	(0.108)	(0.102)	(0.215)
(PeerGroupSize)^2				-0.0318***	-0.0340***
				(0.00714)	(0.0105)
Decade FE	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes
Composer FE			yes		
City FE					yes
Observations	4,963	4,963	4,963	4,963	4,963
R-squared	0.270	0.057	0.185	0.068	0.0175
F-statistic	263.8	124.9	18.8		
Cragg-Donald EV Stat.				38.4	25.6

Note: Standard errors are reported in parentheses. 'PeerGroupSize' counts the number of a composer's peers present in the city in a given year. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table 7. Instrumental variables (Robustness tests)

Dependent variable: Composition

	(1) IV Full sample	(2) IV Full sample	(3) IV Full sample	(4) IV Full sample	(5) IV Young composers	(6) IV Established composers
PeerGroupSize	0.0775***	0.0753***	0.0727***	0.0781***	0.0925***	0.0586***
	(0.0166)	(0.0165)	(0.0175)	(0.0164)	(0.0229)	(0.0189)
Decade FE	yes	yes	yes		yes	yes
Age cohort FE	yes	yes	yes	yes	yes	yes
Music background of family controls		yes				
Music-related education controls			yes			
Year FE				yes		
Observations	4,963	4,963	4,963	4,963	2,793	2,170
R-squared	0.270	0.276	0.278	0.304	0.257	0.270

Note: Standard errors are reported in parentheses. ‘BirthCentrality’ is used as an instrument for the ‘PeerGroupSize’. ‘Young composers’ are individuals below the age of 50. ‘Established composers’ are individuals aged 50 or above. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Figures

Figure 1. The determination of artists' population

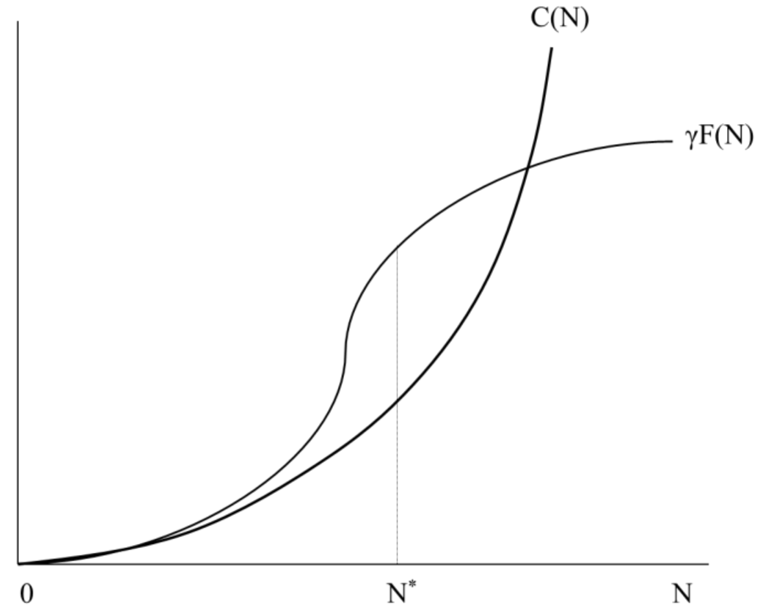


Figure 2. Productivity gains as a function of peer group size

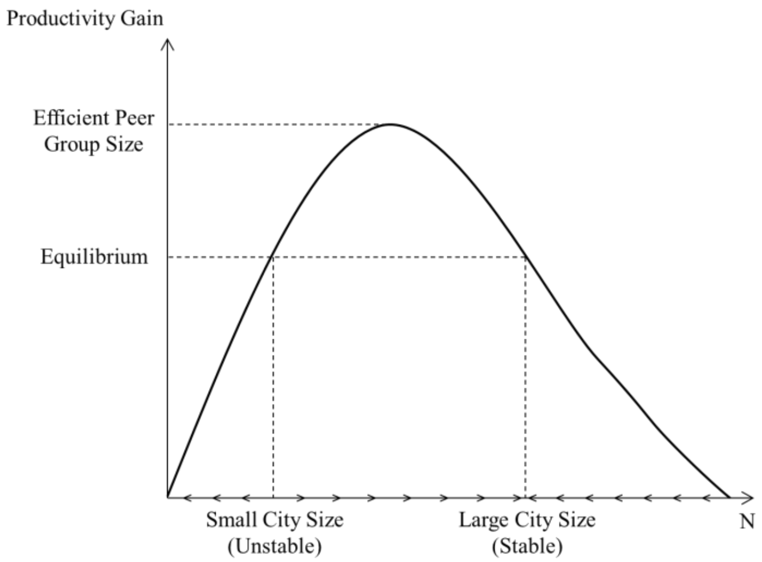
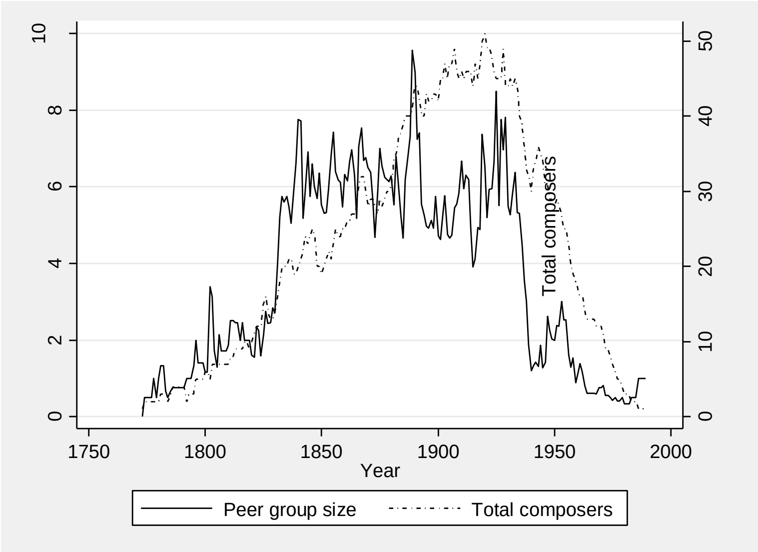
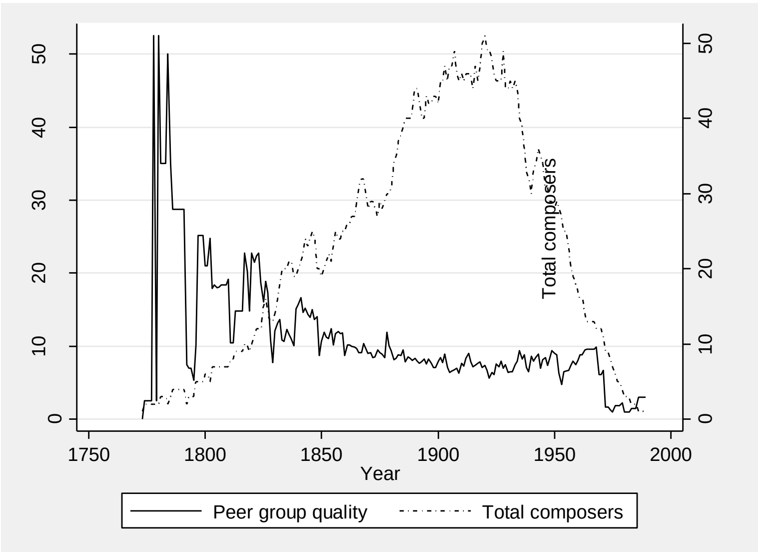


Figure 3. Peer group size over time



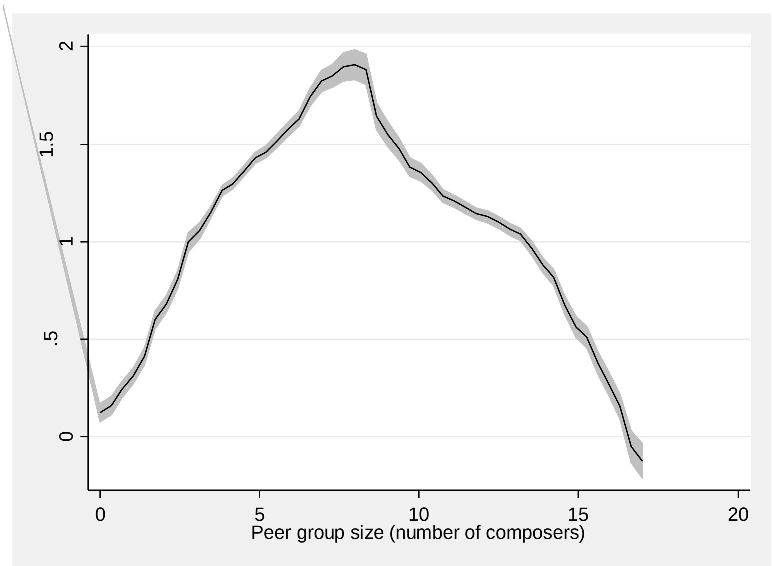
Note: 'Peer group size' measures the number of peers located in the same city in a given year. 'Total composers' counts all composers who are observed in this research in a given year.

Figure 4. Peer group quality over time



Note: 'Peer group quality' measures the average quality (using Murray's Index Scale) of peers located in the same city in a given year. 'Total composers' counts all composers who are observed in this research in a given year.

Figure 5. Productivity gains and peer group size



The depicted prediction is based on a local polynomial regression method with an Epanechnikov kernel and it is presented along with a 95 per cent confidence interval. The estimation is based on the model presented in column 4 of Table 5.

Appendix (For Online Publication)

Appendix 1. Tentative overview of opera houses and concert halls in cities

City	Opera house	Founded	Notes	Concert hall	Founded	Notes
Paris	Palais Garnier	1875	Previously opera was staged also in Paris Opera (built in 1669)	The Conservatoire	1811	Later also Salle Pleyal (1839)
London	Royal Opera House	1732	Building was rebuilt in 1858	The Hanover Square Rooms	1774	Royal Albert Hall served as concert venue from 1871
Vienna	Vienna State Opera	1869	Previously opera was staged in Burgtheater (1741)	Wiener Musikverein	1870	
St. Petersburg	Hermitage Theatre	1784	Replaced by Mariinsky Theatre in 1860	Small Philharmonic Hall	1828	Also known as the ”Engelhardt” Hall
Berlin	Berlin State Opera	1742	Also called Staatsoper Unter den Linden	Berliner Philharmonie	1888	
Moscow	Bolshoi Theatre	1825	Previously opera was staged in Petrovsky Theatre acquired in 1780	Halls of the Assembly of the Nobility	1840	Concert has also been staged at the Bolshoi Theatre
New York	Metropolitan Opera House	1883	Previously opera was staged in the Italian Opera House opened in 1833	Carnegie Hall	1891	Previously concert was staged in the Apollo Rooms (1842)
Rome	The Capranica	1692	Opera has been occasionally staged also in The Alibert (1725) and the Pace (1694).			
Budapest	The Royal Hungarian Opera House	1884	Previously opera was staged in The Városi Színház, Town Theatre (1812)	Vigadó Concert Hall	1859	

Milan	Teatro Regio Ducal	1717	Replaced after fire with La Scala in 1778.			
Venice	San Benedetto Theatre	1768	Later opera perfomances were moved to Teatro La Fenice (1792)			
Copenhagen	Royal Danish Theatre	1748		Royal Danish Theatre	1748	
Boston	The Boston Theatre	1854	Also known as the Federal Street Theatre (1793–1852)	The Odeon	1835	Concerts were performed also at the Boston Theatre
Prague	Nostitzsches Nationaltheater	1783	From 1881 opera was staged in the National Theatre	Rudolfinum	1885	
Leipzig	Leipzig Opera	1693		Gewandhaus	1781	
Naples	Real Teatro di San Carlo	1737				
Dresden	Semperoper	1841	Previously opera was staged in the opera house on the Zwinger (1719)	Dresden Philharmonic	1870	Concerts given also in Semperoper (1841)
Stockholm	Swedish Royal Opera	1773		Kungliga Musikaliska Akademiens Hus	1878	
Amsterdam	Stadsschouwburg	1774		The oval concert hall (1788),	1788	Later concerts were performed at Parkzaal (1851)

Madrid	Teatro Real de Madrid	1850	Previously opera was staged at Teatro de los Caños del Peral (1708)	Teatro Real de Madrid	1850	The Madrid Symphony Orchestra, founded in 1866, performed often in Teatro Real de Madrid
Hamburg	Hamburg State Opera	1678		Konzertsaal auf dem Kamp	1761	Since 1871 concerts performed in the Conventgarten
Bologna	Teatro Comunale di Bologna	1763		Teatro Comunale di Bologna	1763	
Cologne	Theater an der Schmierstraße	1783		Gürzenich	1851	
Palermo	Teatro Massimo	1897	Previously opera was staged in Santa Cecilia Theatre (1726)	Teatro Politeama	1865	
Chicago	Crosby's Opera House	1865		Auditorium Theatre	1889	Early concert halls included Rice's Theatre and McVicker's Theatre
Florence	Teatro della Pergola	1656		Teatro del Corso dei Tintori	1767	Concerts performed also at the Teatro di Borgo dei Greci, the Teatro di Porta Rossa and the Filomusi theatre

Source: Grove (2012).

Appendix 2. Parental influence on composer's birthplace

In this part, I investigate whether there exists any difference in composer's geography of birth and their peer group characteristics depending on the existence of music-related involvement of family members. From biographical entries on composers in Grove (2009) it can be extracted whether any of a composer's family members has been involved in a music-related activity. Since the source dictionary only provides such information if it is of significance, the obtained indicator functions might approximate the role of music in a composer's family. If this was the case, the suggested IV identification strategy would be invalid if composers with family members involved in music were also more often born or located in hubs for classical music. Studying the association between those family indicators and composers' place of birth, work location or peer group characteristics thus allows me to shed light on the influence of family members depending on their preference for music. Since the variables of interest (family music-related background) are invariant over a composer's life-time, the estimations are conducted at composer level and include controls for the composer's half-century of birth and his longevity.

Table A2 summarizes the main results. Column 1 reports point estimates for a regression of dummy variables for family music-related background on the incidence of birth in one of the main hub locations for music (i.e. Paris, Vienna or London). Column 2 presents a regression on the average peer group size. Column 3 summarizes an estimation on the average quality of peers. Column 4 reports an estimation on the number of years a composer spent in Paris, Vienna or London. Column 5 presents the regression estimates on the average distance between a composer's birthplace to the birthplace of a fellow composer. Throughout all five reported estimations it can be seen that the coefficients on the family variables are insignificant, very small and often even negative. The explanatory power of these variables is also very low and would almost disappear in specifications without any control variables. These results would hold for various alterations or sub-samplings.

The results imply that the family controls included have little effect on a composer's place of birth or location choice, nor is it associated with peer group characteristics. Furthermore, there is no sign of a relationship with the average distance between birthplace and cluster cities. In conclusion, a composer's birth place, decision to locate in an important city for music or his peer group size and quality seem to be free from the studied family characteristics. This provides some support for the randomness of the instrument.

Appendix 3. The effect of peer quality

This Appendix provides an analysis and a discussion of the extent to which peer quality is determining productivity outcomes in cities populated by many composers. To achieve this task, three alternative approaches are pursued. First, control variables for peer quality are introduced. Second, I obtain one interaction term between peer size and quality, and instrument for it using the previously introduced centrality of birth variables. Third, the incidence of intra-state war is proposed as an instrumental variable for peer quality.

First, peer quality is introduced as one additional control variable into the previously estimated IV specifications. Columns 1 and 2 in Table A3 present the emerging estimates. The correlation coefficient on peer quality is positive and significant in both specifications. More importantly, the endogenized peer group size variables remain very consistent. As anticipated, the coefficient decreases in size, however, the change is marginal. Furthermore, the quadratic peer group size polynomial remains stable and implies decreasing returns to peer effects. The difficulty with this approach is the potential endogeneity between output and peer quality.

Second, I employ only one variable measuring peer characteristics so that it can be instrumented for it in analogy to the previous IV estimations. For this reason, I use an interaction term between composer's peer group size and average peer quality. The interaction term thus measures the total number of points on Murray's scale for all composers located in a city. In analogy to previous identification strategies, I use composer's centrality of birth variables as instrumental variables. The first-stage correlation coefficients are presented in columns 1 to 3 in Table A4. The IV coefficients are summarized in columns 3 and 4 of Table A3. It can be observed that the aggregated peer quantity and quality variable has strong causal influence on productivity. It is also interesting to observe that peer effects influence productivity at a decreasing rate. The association between the variables studied is visualized in Figure A2. While this approach provides important support for the overall findings, little can be said about the relative importance of peer group size and quality of peers.

Next, a specification is employed in which each of the peer variables is instrumented for separately. For this reason we need one further instrumental variable which would provide exogenous variation to the average quality of composers located in a city. In other words, we need a variable that affects composers of a certain quality, but not all. I suggest using the incidence of war, as it might be a factor that affects people in an asymmetric way. In times of war, some composers, presumably those of higher quality, might have better opportunities to emigrate and therefore decide to relocate to a city where peace prevails. This is a difficult identification strategy, as war might also have an impact on composer's productivity, which would invalidate the instrumental variable.[31]

Using the Correlates of War database (Sarkees and Schafer, 2000), I obtain an indicator function which identifies the countries that have been involved in a civil war in a particular year. The focus on civil wars is motivated by the fact that intra-state wars are possibly the most unexpected types of war and, hence, likely to be exogenous. The average composer has experienced 1.26 civil wars (St. Dev. 2.69) during his life.

The impact of intra-state wars on average peer quality is visualized in Figure A3. There is little variation in average peer quality three years before the incident of civil war. In the year of the war the peer quality falls dramatically by more than a third. The decrease is not permanent, and a return to the previous average peer quality can be observed.

The first-stage relationship is formally presented in columns 4 to 8 of Table A4. The endogenous variables exhibit a significant relationship with at least one of the proposed instrumental variables. Columns 5 and 6 of Table A3 report the coefficients for two specifications with and without a second-order polynomial of peer group size. The results indicate a strong causal effect of peer group size and a somewhat less precisely estimated (albeit significant) causal effect of peer group quality on output.[32] Since we have filtered out the impact of peer quality from the peer group size variable, the point estimate on the number of peers is now somewhat smaller than in estimations without controls for peer quality. It is encouraging that the inverted U-shaped association between number of peers and productivity gains remains very robust. Figure A4 visualizes the function.

Finally, one might want to use the second time-varying instrument in order to endogenize the quadratic peer group size polynomial and include composer fixed effects. Previously, this was not possible as one of the used instrumental variables (centrality of birth) were invariant over a composer's lifetime. However, using birth centrality interacted with age and the incidence of intra-state war allows for an estimation of a model that contains a set of controls for unobserved differences between composers. The specification with composer fixed effects is presented in column 3 of Table A6 (columns 1 and 2 report the first-stage estimations). The disclosed productivity gains are consistent with the previously shown

[31] Of some justification is the absence of any statistically significant association between civil war and composers' output in a reduced form model with the usual control variables (reported in Table A5).

[32] Including a quadratic peer quality polynomial (and peer group size at level) does not yield more precise estimates of peer quality effects. In fact, estimations of a quadratic impact of peer quality are not very robust and are not pursued any further.

concave association. It is reassuring that the results are robust to the inclusion of composer fixed effects.

Appendix 4.Work heterogeneity

The requirements for cultural infrastructure differ depending on the type of composition. A composer would require access to an opera house and opera company in order to test and perform opera works. Concert works were usually played by symphonic orchestras in concert halls. So was chamber music, which was, however, also frequently performed in more informal settings. Differentiating compositions by type therefore serves as an additional robustness test that illuminates the presence of any differences across various types of works. Based on the brief description of each composition in Gilder and Port (1978), each work is categorized into concert, chamber, opera and church works. The most frequent types of compositions of this time period are concert works, followed by chamber and opera works (Panel D, Table 1). As one might expect, church pieces were of the least importance in this period.

Using an identification strategy in analogy to the previously presented estimations, I estimate the causal effects of peer group size on the production of each of these types of music using birth centrality as an instrumental variable. The IV coefficients are presented in Table A8. In columns 2 to 5, it can be seen that the point estimates on each type of work are positive and, except for the church type of category, statistically significant. It is also encouraging to observe that all coefficients on the disaggregated categories add up perfectly to the IV-coefficient on the aggregate variable in the baseline specification in column 1.

Appendix 5. Large city effects

The cities where composers were located were highly heterogeneous and differed in various respects. One would typically want to account for all these differences, including various type of quality of cultural facilities available within a city. Especially, better cultural infrastructure is not only likely to be conducive to productivity, but it might also attract further composers to a city and hence affect the peer group size. In this research design, this is, however, not an issue, since instrumental variables are used in order to estimate for the number of peers which mitigates the worry of omitted variable bias.

It is also fairly out of scope to control for any specific city characteristics, since such data are not consistently available for the large range of cities covered here, especially in a historical period and at an annual level. It was previously observed that the results are robust also if city fixed effects are introduced as control variables (column 5 of Table 5). This already provides some support for the argument that peer group size, rather than some unobserved city characteristics determines productivity outcomes. In additional specifications, the robustness of these results is studied further. Since the most meaningful differences are potentially observed between large and small cities, an additional control variable is obtained based on the population records provided by Mitchell (2007). A specification that accounts for population size is presented in column 1 of Table A9.[33] One might also want to drop some of the cities with extreme characteristics. I therefore further exclude a large number of observations for Paris, since it was a city with by far the largest group of composers. As can be seen in column 2, the coefficient is now substantially larger. This could be a consequence of the large size of the Parisian cluster: a size that is possibly associated with agglomeration diseconomies. In column 3, I drop observations for Vienna, since it was a significant city for classical music and yet of relatively small size. Finally, I exclude observations for London and show the results in column 4. The coefficients for these restricted models are somewhat smaller. Vienna and London were possibly closer to the optimum size of a music cluster. It is nonetheless encouraging to observe that all three sub-sampling variations deliver positive and very significant IV coefficients. This implies a predominant impact of peer group size on productivity.

[33] Several alternative sub-sampling procedures based on city size have been conducted. Dividing the data into large and small cities, at various cut-off points, delivers consistent results throughout.

Appendix 6. Additional Figures and Tables

Table A1. Poisson regressions

Dependent variable: Composition

	(1) Poisson	(2) Poisson	(3) Poisson
PeerGroupSize	0.0348***	0.0261***	0.0857***
	(0.00761)	(0.00875)	(0.0155)
(PeerGroupSize)^2			-0.00216***
			(0.000708)
PeerQuality	0.0242***	0.00731***	0.0101***
	(0.00133)	(0.00172)	(0.00145)
Decade FE	yes	yes	yes
Age cohort FE	yes	yes	yes
Composer FE		yes	
Observations	4,963	4,963	4,963
Pseudo R2	0.109	0.246	0.141

Note: Standard errors are reported in parentheses. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A2. Parental influence on composer's birthplace

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
Dependent variable:	Birth in Paris, Vienna or London	PeerGroupSize	PeerQuality	Time spent in Paris, Vienna or London	BirthCentrality
Music-related engagement of parents	-0.0227	0.178	0.339	1.469	-0.0214
	(0.0683)	(0.781)	(0.480)	(3.684)	(0.0201)
Music-related engagement of any other family member	0.0352	-0.638	0.101	-0.400	-0.0335
	(0.0736)	(0.842)	(0.518)	(3.973)	(0.0216)
Period of birth controls	yes	yes	yes	yes	yes
Longevity controls	yes	yes	yes	yes	yes
Observations	116	116	116	116	116
R-squared	0.017	0.059	0.026	0.095	0.034

Note: Standard errors are reported in parentheses. The dependent variable in column 3 'Birth in main cluster' takes the value one for composers who have been born in Paris, Vienna or London, and zero otherwise. The dependent variable in column 4 'Working in main clusters' is the sum of a composer's years spent in Paris, Vienna or London. 'Period of birth controls' account for each of the 50-year time intervals. 'Longevity controls' account for 50-year-interval time of birth dummies. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A3. Instrumental variables (Peer group size and quality effects)

Dependent variable: Composition

	(1) IV (PeerQuality without IV)	(2) IV (PeerQuality without IV)	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV
PeerGroupSize	0.156***	0.552***			0.137***	0.668***	0.319***
	(0.0264)	(0.100)			(0.0267)	(0.158)	(0.0677)
(PeerGroupSize)^2		-0.0349***				-0.0482***	-0.0156**
		(0.00694)				(0.0127)	(0.00608)
PeerQuality	0.0230***	0.0188***			0.0401*	0.0897**	
	(0.00176)	(0.00224)			(0.0229)	(0.0401)	
(PeerGroupSize * PeerQuality)			0.00600***	0.105***			
			(0.00143)	(0.0262)			
(PeerGroupSize * PeerQuality)^2				-0.000689***			
				(0.000182)			
Decade FE	yes	yes	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes	yes	yes
Composer FE							yes
Observations	4,963	4,963	4,963	4,963	4,868	4,868	4,868
R-squared	0.128	0.059	0.313	0.168	0.066	0.089	0.467
Cragg-Donald EV Stat.	122.2	42.2	151.8	10.44	11.3	10.3	8.3

Note: Standard errors are reported in parentheses. Columns 1 reports an IV-regression where ‘BirthCentrality’ as an instrument for the ‘PeerGroupSize’. Column 2 report an IV-regression where ‘BirthCentrality’ and ‘BirthCentrality’*’Age’ is used in order to instrument for the quadratic peer group size polynomial. Both columns contain ‘PeerQuality’ only as an additional control variable that is without being instrumented for the quality measure. Columns 3 and 4 report specifications where ‘BirthCentrality’ and ‘BirthCentrality’*’Age’ are used in order to instrument for the interaction term between peer groups size and quality. The respective first-stage regressions are shown in columns 1 to 3 of Table A4. Column 5 reports an IV-regression where ‘BirthCentrality’ and civil war are used as instruments for peer group size and quality, as shown in columns 4 and 5 of Table A4. Column 6 reports an IV-regression where ‘BirthCentrality’, ‘BirthCentrality’*’Age’ and civil war are used in order to instrument for the three peer variables, as shown in columns 6 to 8 of Table A4. Finally, column 7 reports an IV-regression where ‘BirthCentrality’*’Age’ and civil war are used in order to instrument for the quadratic peer group size polynomial. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A4. First-stage estimates for models accounting for peer quality

Dependent variable:	(1) OLS (PeerGroupSize * PeerQuality)	(2) OLS (PeerGroupSize * PeerQuality)	(3) OLS (PeerGroupSize * PeerQuality)^2	(4) OLS PeerGroupSize	(5) OLS PeerQuality	(6) OLS PeerGroupSize	(7) OLS PeerGroupSize^2	(8) OLS PeerQuality
BirthCentrality	-18.11***	-19.89***	-3.023***	-1.600***	-1.241***	-1.553***	-25.71***	-1.964***
	(1.045)	(1.412)	(220.2)	(0.101)	(0.251)	(0.136)	(2.147)	(0.338)
BirthCentrality * Age		0.0357*	9.100***			-0.000953	0.0636**	0.0145***
		(0.0190)	(2.967)			(0.00183)	(0.0289)	(0.00454)
Civil war				-0.771*	-4.952***	-0.771*	-12.17*	-4.946***
				(0.412)	(1.024)	(0.412)	(6.500)	(1.023)
Decade FE	yes	yes	yes	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	4,963	4,963	4,963	4,868	4,868	4,868	4,868	4,868
R-squared	0.186	0.187	0.160	0.182	0.076	0.182	0.156	0.078
Cragg-Donald EV Stat.	151.8	10.44	10.44	11.3	11.3	10.3	10.3	10.3

Note: Standard errors are reported in parentheses. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A5. Reduced form model

Dependent variable: Composition		
	(1)	(2)
	OLS	OLS
BirthCentrality	-0.167	
	(0.147)	
Civil war		-0.110
		(0.0867)
Decade FE	yes	yes
Age cohort FE	yes	yes
Observations	4,963	4,868
R-squared	0.106	0.062

Note: Standard errors are reported in parentheses. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A6. Instrumental variables (With composer fixed effects)

	(1)	(2)	(3)
	OLS	OLS	IV
Dependent variable:	PeerGroupSize	(PeerGroupSize)^2	Composition
PeerGroupSize			0.319***
			(0.0677)
(PeerGroupSize)^2			-0.0156**
			(0.00608)
BirthCentrality * Age	-0.00947***	0.0218	
	(0.00215)	(0.0381)	
Civil war	-1.296***	-19.19***	
	(0.268)	(4.759)	
Decade FE	yes	yes	yes
Age cohort FE	yes	yes	yes
Composer FE	yes	yes	yes
Observations	4,868	4,868	4,868
R-squared	0.706	0.615	0.267
Cragg-Donald EV Stat.			8.27

Note: Standard errors are reported in parentheses. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A7. Instrumental variables (Additional robustness tests)

Dependent variable: Composition

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Short visits excluded	Death year excluded	Multiple cities excluded	Extreme events excluded	Low composer number excluded	Low PeerGroupSize excluded	Pre-1831 and post-1936 excluded	High PeerQuality excluded
PeerGroupSize	0.0721***	0.0779***	0.0680***	0.0827***	0.0572***	0.0614***	0.0440***	0.0509***
	(0.0161)	(0.0169)	(0.0161)	(0.0171)	(0.0164)	(0.0178)	(0.0115)	(0.0131)
Decade FE	yes	yes	yes	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	4,829	4,872	4,778	4,414	3,040	2,531	3,683	4,776
R-squared	0.269	0.270	0.269	0.262	0.343	0.342	0.308	0.329

Note: Standard errors are reported in parentheses. Column 5 reports a specification without years when less than 30 composers are observed. Column 6 reports a specification without observations when peer group size lies below three. Column 8 reports a specification without observations when average peer quality lies above 30 on Murray's Index Score. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Table A8. Instrumental variables (Alternative productivity measures)

	(1)	(2)	(3)	(4)	(5)
	IV	IV	IV	IV	IV
Dependent variable:	Composition	Concert works	Chamber works	Opera works	Church works
PeerGroupSize	0.0775***	0.0335***	0.0316***	0.0123**	5.44e-05
	(0.0166)	(0.0105)	(0.00880)	(0.00480)	(0.00180)
Decade FE	yes	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes	yes
fg					
Observations	4,963	4,963	4,963	4,963	4,963
R-squared	0.270	0.238	0.098	0.114	0.025

Note: Standard errors are reported in parentheses. ‘BirthCentrality’ is used as an instrument for the ‘PeerGroupSize’. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

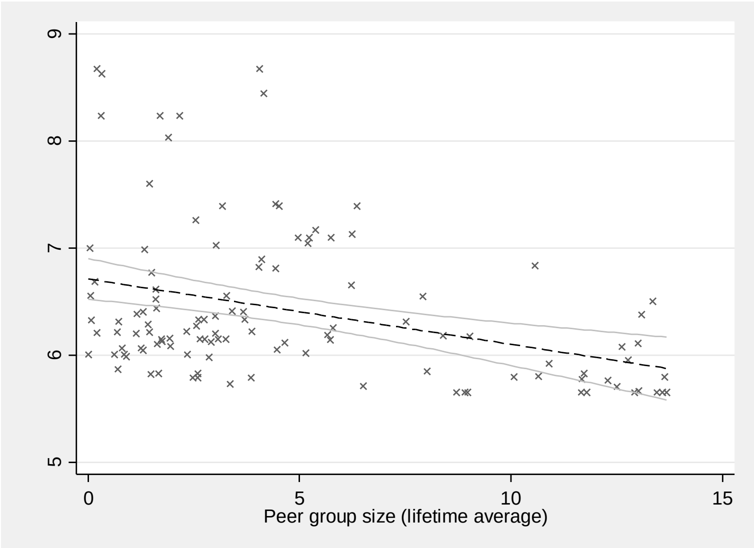
Table A9. Instrumental variables (Large city effects)

Dependent variable: Composition

	(1) IV Full sample	(2) IV Paris excluded	(3) IV Vienna excluded	(4) IV London excluded
PeerGroupSize	0.156***	0.635***	0.0530***	0.0376**
	(0.0387)	(0.0991)	(0.0136)	(0.0147)
Decade FE	yes	yes	yes	yes
Age cohort FE	yes	yes	yes	yes
City size controls	yes			
Observations	4,963	3,409	4,619	4,556
R-squared	0.184	0.065	0.330	0.346

Note: Standard errors are reported in parentheses. 'BirthCentrality' is used as an instrument for the 'PeerGroupSize'. ***/**/* indicate estimates that are significantly different from zero at 99/95/90 percent confidence.

Figure A1. Centrality of birthplace and peer group size



Note: The figure depicts a linear prediction for a measure of birth centrality, calculated as the average distance between a composer's birthplace and the birthplace of a fellow composer, along with a 95 per cent confidence interval. The prediction is obtained from a linear regression of birth centrality on peer group size.

Figure A2. Productivity gains and total points on Murray's Index Score

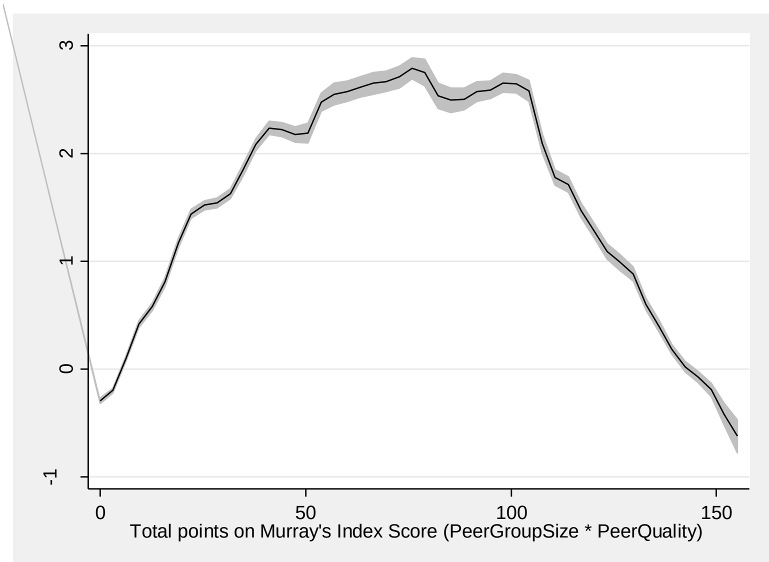


Figure A3. Effect of civil war on peer quality

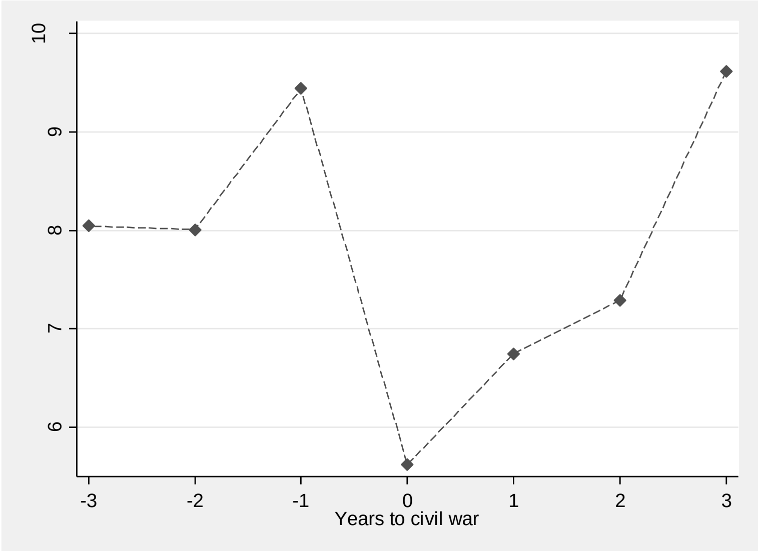
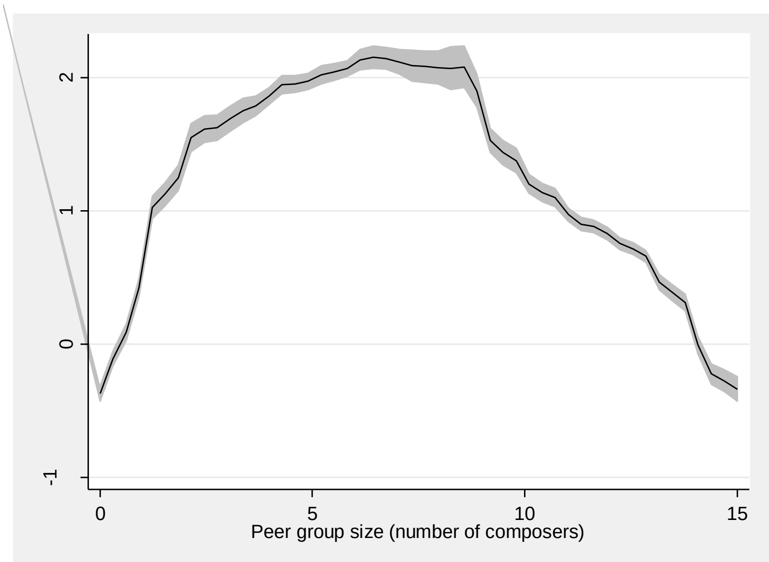


Figure A4. Peer group size effect on composer's output after peer quality effects are filtered out



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