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Abstract

This paper investigates the relationship between the social inclusion of lesbian, gay, bisexual and transgender (LGBT) people and technological innovation. It establishes that LGBT inclusion helps foster human capital skills, thus strengthening national innovative capacity. Exploiting cross-country data, this research provides suggestive evidence that social tolerance toward homosexuality is positively correlated with the economic complexity index, a novel measure of cross-country differences in innovative capabilities. An individual-level analysis, based on data from the World Values Survey, reveals that respondents who self-report tolerance toward homosexual acts tend to have positive attitudes toward technological innovation, *ceteris paribus*. This lends credence to the international evidence. Further analyses indicate that the link between LGBT inclusion and innovation is partially mediated through the accumulation of human capital. The main findings suggest that the social exclusion of LGBT people, at least to some extent, hinders innovation, thus impeding economic development.

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Key words: LGBT, innovation, economic complexity, gender discrimination.

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"*The exclusion of LGBT people from full and equal participation in basic economic, education, health, social, and political settings does not just hurt them – it hurts everyone. In short, when LGBT people are fully included, we will all be better off.*" ~ Badgett (2020)

1. Introduction

The existence of large and persistent disparities in economic prosperity across the world remains one of the most perplexing issues facing economists. Some early contributions to this line of inquiry hold that the exclusion of women and/or marginalized groups within an economy matters for international differences in income per capita. Specifically, many studies show that gender discrepancies in various dimensions of empowerment and well-being, particularly education, health and employment opportunities, exert a negative influence on economic growth and development (see, e.g., Knowles *et al.*, 2002; Duflo, 2012). More recently, Badgett *et al.* (2019) postulate that the social inclusion of lesbian, gay, bisexual, and transgender (LGBT) people positively affects income levels. Their empirical analysis is mainly based on using an internationally comparable index of LGBT inclusion that reflects legal rights and protections afforded to homosexual individuals across countries.

Much of the existing literature has focused on estimating the effects of gender differences in different aspects of well-being on the worldwide distribution of GDP per capita. By contrast, the extent to which the social exclusion of homosexual people matters for economic performance is still open to question. Badgett *et al.* (2019), to my knowledge, is the only study investigating the relationship between discrimination against the LGBT community and comparative development across the globe. The interest of their paper, however, lies exclusively in the effects of LGBT inclusion on income per capita. Unfortunately, little is known about the mechanisms through which the social exclusion of LGBT people helps shape global income inequality. If innovation, as proposed by this research, is a key channel through which homosexuality-supportive policies transmit to economic growth, we need to understand this reduced-form link. To speak to those debates, the current study attempts to examine the effects of the social inclusion of LGBT people on national innovative capacity based on cross-country and individual-level analyses.

Additionally, the empirical exercises of this paper are motivated by three main arguments. *First*, there has been significant progress in social tolerance toward homosexuality in many Western societies (Badgett *et al.*, 2019). However, substantial discrimination against LGBT people remains widespread in much of the developing world. Specifically, homosexual

acts are still illegal, and may result in severe punishments, including the death penalty, in many parts of Asia, Africa and the Middle East (Bailey *et al.*, 2016). Moreover, a recent study by Ayoub and Kollman (2020) reveals that there exist significant differences in the recognition of LGBT rights across European countries. *Second*, the Sustainable Development Goals emphasize the importance of espousing equality in gender roles. Therefore, reducing discrimination against LGBT people is essential for achieving this goal. Further, the extent to which we can create an LGBT-supportive environment across the world arguably depends on our understanding about the contribution to economic performance of the social inclusion of homosexual people. This paper puts forward the idea that promoting human rights and protections of the LGBT community helps spur technological innovation and economic growth. The findings of this study, at least partially, advocate the social inclusion of LGBT people, particularly in developing economies where homophobia prevails. *Third*, technological innovation is widely perceived as a key driver of productivity (or income) levels, and health outcomes (Vu, 2020). This points to the desirability of exploring the institutional and social environment that enhances national innovative capacity.

The main objective of this paper is to explore the link between the social inclusion of LGBT people and cross-country differences in innovation. I posit that reducing discrimination against homosexual behaviors enhances human capital accumulation, thus strengthening national innovative capacity. Furthermore, creating an LGBT-friendly environment would attract inflows of human capital because it signals the acceptance of diversity, creativity and open-mindedness. It follows from this line of reasoning that improvements in the social tolerance toward LGBT people can contribute to prosperity through bolstering innovation. The proposed hypothesis is tested by performing the empirical analysis at both the macro- and micro-level. More specifically, I use the LGBT inclusion index developed by Badgett *et al.* (2019) to estimate cross-country OLS regressions. In line with the central hypothesis, the study finds that LGBT inclusion is positively correlated with the economic complexity index, a novel measure of country-level innovative capabilities. The paper also carries out an individual-level analysis, exploiting data from the World Values Survey. The results demonstrate that tolerance toward homosexuality is positively correlated with respondents' attitudes toward science and technology, and new ideas, creativity, taking risks, adventure and changes. This lends support to the cross-country evidence. I also find that LGBT inclusion affects innovation by reinforcing the quality of human capital.

The approach adopted within this research offers a fresh perspective to the following strands of research. Specifically, this paper builds upon the literature investigating the economic impacts of wide discrepancies in gender roles throughout the world (Knowles *et al.*, 2002; Duflo, 2012). I add evidence to this debate that the social inclusion of marginalized groups of a population, particularly LGBT people, exerts a positive influence on national innovative capacity, which is arguably an important driver of long-term growth. Furthermore, this research relates to several studies documenting a relationship between discrimination against LGBT people and firm performance (Button, 2001; Griffith & Hebl, 2002; Brenner *et al.*, 2010; Pichler *et al.*, 2018). Accordingly, discrimination against homosexual people at the work place is associated with lower levels of job satisfaction and organizational commitment among LGBT employees. By contrast, LGBT-supportive policies in the work environment reduce job anxiety among gay and lesbian employees. These factors are ultimately conducive to firm productivity. The current research goes beyond previous research by establishing the link between LGBT inclusion and innovation at the macro level, yielding a generalized understanding across the world.

A final distinguishing feature of the current study stems from adopting the economic complexity index as a new measure of innovative capacity. The findings of the current research contribute to an emerging strand of literature examining the role of economic complexity in explaining cross-country comparative development (Hidalgo & Hausmann, 2009; Hartmann *et al.*, 2017; Lee & Vu, 2020; Vu, 2020). Importantly, very few studies pay attention to the social and institutional environment that shapes the level of economic complexity. This paper documents suggestive evidence that reducing the social exclusion of LGBT people is linked to increases in country-level innovative capabilities captured by the economic complexity index.

2. Why does LGBT inclusion matter for innovation?

The central hypothesis is that the social inclusion of LGBT people helps promote innovation through enhancing the quality of human capital. Conventional wisdom in development economics holds that human capital is a key conduit of innovation, which critically affects productivity and income differences across the globe (Gennaioli *et al.*, 2012). It follows from this line of reasoning that countries endowed with better human capital tend to innovate more, because technological innovation arguably depends on people's curiosity, imagination, risk-taking and cooperation. By this logic, the social inclusion of LGBT people promotes national innovative capacity by accelerating the quality of human capital of an economy.

It is noteworthy that the quality of human capital reflects knowledge, skills and health capital, all of which contribute to national innovation and long-term growth through shaping individuals' productivity (Becker *et al.*, 1990). This reveals that any barriers to the accumulation of human capital may hinder national innovative capacity. As put forward by Badgett *et al.* (2019), the social exclusion of LGBT individuals, measured by the absence of legal rights and protections afforded to LGBT people, prevents them from acquiring better human capital skills. A key explanation for this argument is that discrimination against homosexuality lowers educational attainment, and leads LGBT people to drop out of schools (Kosciw *et al.*, 2013; Badgett *et al.*, 2019). This is consistent with numerous studies documenting that gender discrimination is detrimental to educational attainment, thus hindering economic development (Knowles *et al.*, 2002; Duflo, 2012). Additionally, there exists evidence at the subnational level that LGBT people experience considerable discrimination in schools by their teachers and fellow students. For example, a survey conducted in European countries reveals that approximately 90% of LGBT individuals had witnessed negative comments or conduct in schools.[1] Khan *et al.* (2005) indicate that 50% of males who have sex with males in Bangladesh and India reported that they had been assaulted or harassed by teachers or other students. This significantly increases the probability of dropping out of schools due to the negative impacts of this harassment (Khan *et al.*, 2005).

The social inclusion of the LGBT community may foster human capital through better health outcomes and employment-related opportunities (Badgett *et al.*, 2019).[2] Several studies reveal that LGBT people typically suffer violence in Indonesia (Arivia & Boangmanalu, 2016) and India (Khan *et al.*, 2005). This may translate into significant loss of human health, thus impeding national innovative capacity. Indeed, the LGBT community tends to suffer from health disparities, including HIV, depression, anxiety and suicidality, compared with their heterosexual counterparts (Badgett *et al.*, 2019). Health issues arguably reduce the productivity of LGBT people, which hinders national innovative capacity. It is well established that discrimination in employment is associated with reduced monetary profit when discriminatory employers refuse to recruit socially excluded workers who are more or at least as productive as others (Becker, 1971; Badgett *et al.*, 2019). Hence, marginalized groups who face

[1] The final report can be accessed via this link https://fra.europa.eu/sites/default/files/eu-lgbt-survey-results-at-a-glance_en.pdf.

[2] It is widely acknowledged in the epidemiological literature that non-heterosexual people face significantly poorer health compared with their heterosexual counterparts (Hipple *et al.*, 2011). This reduces productivity of LGBT people, and increases social costs, thereby hindering a country's innovative capacity.

discrimination at the work place may end up with jobs in which they are less likely to exploit their full capabilities and skills. An early study by Bergmann (1971) reveals that people facing discrimination in employment opportunities may end up with unproductive occupations or even become unemployed. This suggests that LGBT inclusion may foster the accumulation of human capital through education and health outcomes, and jobs-related opportunities, leading to productivity improvements. From a cross-country perspective, societies characterized by the prevalence of discrimination against homosexuality are arguably less productive and innovative. By contrast, countries that promote the social inclusion of LGBT workers may experience improvements in national innovative capacity.

According to an early view proposed by Mokyr (1990), diversity and tolerance constitute the fundamental drivers of the innovation process. Innovative activities, in particular, tend to proliferate in places with less discrimination against nonconformists. The main intuition is that technological advances depend on the social acceptability of unconventional people because innovators are mostly eccentric individuals (Mokyr, 1990). This implies that social tolerance afforded to homosexual people may spur creativity, knowledge, skills and innovation. There also exists some empirical evidence supporting the argument that the social inclusion of LGBT people fosters technological change and economic outcomes. Florida (2002), for instance, documents a positive link between the share of bohemians and the quality of human capital across regions in the US. Constructing a novel measure of the bohemian population at the regional level, the author finds that the correlation between the bohemian index and the talent index is 0.553. For example, areas with the highest values of the bohemian index (e.g., San Francisco, Seattle, and Boston) are likely to enjoy better human capital. By contrast, regions characterized by the lowest bohemian index (e.g., Buffalo, San Antonio and Cleveland) tend to suffer from lower levels of human capital accumulation. Moreover, the social tolerance toward marginalized individuals, including homosexual people, acts as a catalyst for technological-based industries (Florida, 2002). The results reveal that the most high-tech regions (e.g., San Francisco, Boston, Seattle, and New York) are also in the top ten bohemian regions (Florida, 2002). Furthermore, Florida *et al.* (2008) indicate that the social inclusion of gays and lesbians is conducive to human capital skills and regional development in the US.

The positive link between LGBT inclusion and innovation also builds upon numerous studies demonstrating that treating these marginalized individuals equally at the work place helps improve firm performance (Griffith & Hebl, 2002; Pichler *et al.*, 2018). This viewpoint, in particular, asserts that reducing any discrimination against LGBT people in the work

environment could nurture business outcomes because it helps improve productivity of these workers. Furthermore, LGBT-friendly policies implemented at the firm level would reduce the negative consequences associated with any discrimination against homosexuality, such as health care and absenteeism costs (Badgett *et al.*, 2019). According to Button (2001), equal treatment in the work place would benefit LGBT employees by improving their mental health and enhancing their commitment to companies.

Griffith and Hebl (2002) also find that LGBT-supportive policies are associated with lower levels of job anxiety and help improve job satisfaction among gay and lesbian employees. Furthermore, tolerance toward homosexuality at the workplace motivate LGBT individuals to disclose their sexual orientation, which eventually enhances mental health and productivity of LGBT employees (Ragins *et al.*, 2007). Exploiting a sample of 534 LGBT employees in the US, Ragins *et al.* (2007) document that homosexual employees reported less fear, and were more inclined to disclose their sexual identity when working with LGBT-supportive groups. Hence, non-discrimination toward homosexuality enhances firm productivity. Additionally, LGBT inclusion plays an important role in strengthening the relationship between these marginalized groups and their co-workers and employers (Brenner *et al.*, 2010). This is particularly essential for technology-intensive industries that typically require coordination in the work place. Additionally, better cooperation at the firm level may improve the utilization of the existing human capital and bolster innovative capabilities. For this reason, if reducing discrimination against homosexual people fosters firm performance, such policies would strengthen national innovative capacity.

Another argument for why an LGBT-friendly environment matters for national innovative capacity lies in the assertion that tolerance toward homosexuality signals low barriers to entry of human capital. The basic idea is that places with greater social diversity and tolerance are more likely to attract inflows of talents (Florida, 2003). The social inclusion of the LGBT community creates an open business environment that nurtures diversity and creativity, which is of importance for immigration and innovation (Florida, 2003; Badgett *et al.*, 2019). This is particularly relevant for the development of technology-intensive industries and economic prosperity when examining the effect of LGBT inclusion on innovation from a cross-country framework. Noland (2005), for instance, demonstrates that the social tolerance of homosexuality exerts a positive influence on foreign direct investment. Therefore, I argue that innovative activities proliferate in countries with better inclusiveness of the LGBT community.

3. Empirical specification and data

3.1. The model

To explore the relationship between LGBT inclusion and national innovative capacity, I set up the following model:

$$ECI_i = \alpha + \beta LGBT_i + \gamma X_i + \varepsilon_i$$

where ECI denotes the economic complexity index, the main measure of innovative capabilities for country i $(i = 1,2, \dots, 116)$. $LGBT$ stands for the LGBT inclusion index developed by Badgett *et al.* (2019). β captures the estimated effects of LGBT inclusion on national innovative capacity. X corresponds to the set of main control variables, including trade openness (*Trade*), financial development (*Finance*), government size (*Gov_size*) and the log of population (*Pop_size*). ε is the error terms. See also Table 1 and the online Appendix for detailed descriptions and summary statistics of all variables, and data sources.

It is important to discuss the motivations of estimating cross-sectional models to investigate the link between LGBT inclusion and innovation. *First*, the main interest of the current study lies in the impacts of the social inclusion of LGBT people on the cross-country variation in innovative capabilities. Estimating cross-country regressions is relevant for this purpose. This empirical exercise is also relevant for capturing the long-term relationship between *ECI* and *LGBT*, which tends to be relatively stable over the years. *Second*, the *LGBT* index, constructed by Badgett *et al.* (2019), exhibits little variation within a country over time. This is consistent with the argument that social tolerance toward homosexuality appears to be an enduring featuring of a society.

A major threat to achieving causal inference stems from potential omitted variables bias. Specifically, if an unobserved variable is correlated with both social tolerance toward LGBT people and *ECI*, the coefficient on *LGBT* can be biased and inconsistent. Therefore, I incorporate numerous possibly confounding factors in the regression to avoid obtaining spurious estimates. It is noteworthy that reverse causation is unlikely to exist in this case because it is difficult to envisage a direct mechanism of influence running from innovation to LGBT inclusion. One may well argue that the development of technology-intensive industries may be associated with increases in income per capita or improvements in the rule of law (institutions). Such changes potentially translate into better legal rights and protections afforded to homosexual individuals. Hence, the potential bias is induced by cross-country differences in institutional quality or income per capita rather than reverse causality per se.

The choice of main control variables is partially motivated by Vu (2019) who examines the determinants of economic complexity – a novel measure of national innovative capacity. A potential confounder is trade openness, which promotes innovation through enhancing the dissemination of knowledge and skills across borders (Sweet & Maggio, 2015). Moreover, financial development may foster technological innovation as suggested by Hsu *et al.* (2014). Government size may exert a positive influence on the development of technology-intensive industries through providing public resources for innovation (Sweet & Maggio, 2015; Vu, 2019). Cross-country differences in innovative capabilities, captured by *ECI*, may be driven the size of the population. This is because population size may reflects the diversity of ideas and creativity. A bigger market size may correspond to the product diversification that the measure of innovation used in this paper captures. Furthermore, population size may capture the extent to which my findings just proxy for the effect of increasing returns to scale of export productivity (Sweet & Maggio, 2015). Therefore, I include these variables as baseline controls. Table 1 contains a description of key variables included in the main model specification.

3.2. Measuring international variation in LGBT inclusion

There exists no internationally comparable measure of well-being disparities (e.g., earning, education or health discrepancies) between homosexual individuals and heterosexual ones (Badgett *et al.*, 2019). Moreover, measuring the size of the LGBT community across countries appears to be challenging arguably due to the absence of sexual orientation questions in most demographic surveys. Following Badgett *et al.* (2019), this paper exploits a global dataset of legal rights and protections afforded to homosexual individuals to measure cross-country differences in the social inclusion of LGBT people (Table 1).

More specifically, Badgett *et al.* (2019) introduce the Global Index on Legal Recognition of Homosexual Orientation (*LGBT*). The construction of index relies on a three-stage procedure. The first step involves identifying the types of laws related to the social inclusion of LGBT people. Next, these authors attempt to collect internationally comparable data on these laws. The final stage requires assigning numerical values to these laws, yielding an internationally comparable proxy for the social inclusion of homosexual individuals. As put forward by Badgett *et al.* (2019), the *LGBT* index utilizes eight categories of legal rights that have been implemented to reduce discrimination against LGBT people across the globe. They include (i) Legality of consensual homosexual acts between adults; (ii) Equal age limits for consensual homosexual and heterosexual acts; (iii) Explicit legal prohibition of sexual

orientation discrimination in employment; (iv) Explicit legal prohibition of sexual orientation discrimination regarding goods and/or services; (v) Legal recognition of the non-registered cohabitation of same-sex couples; (vi) Availability of registered partnership for same-sex couples; (vii) Possibility of second-parent and/or joint adoption by same-sex partners; and (viii) Legal option of marriage for same-sex couples. See Badgett *et al.* (2019) for more details. To estimate cross-sectional models, I calculate a simple average of this index between 1966 and 2011. Figure 1 depicts the cross-country variation in LGBT inclusion, captured by legal rights and protections afforded to homosexual individuals.

3.3. Measuring international variation in innovation

Conventional proxies for innovation include the number of patents and R&D expenditure. Nevertheless, the drawbacks of using these measures are well documented (Sweet & Maggio, 2015). For instance, economists have typically made use of R&D expenditure as an input-based measure of innovative capabilities. However, the extent to which R&D spending translates into real innovative capacity critically depends on the institutional environment that shapes the efficiency of utilizing this input (Sweet & Maggio, 2015). Hence, we can hardly infer anything about the output side of the innovation process from R&D expenditure (e.g., commercially oriented innovation such as the introduction of new products, services or processes).

The number of patents has been popularly used as an (intermediate) output-based indicator of innovative capabilities. Nevertheless, a "culture of patenting" is much less common in the developing world (Sweet & Maggio, 2015). This may lead to measurement errors bias in cross-country studies. Furthermore, technological progress may be driven by non-patented or unpatented inventions (Kleinknecht *et al.*, 2002). Importantly, innovation is defined as an incremental process, obtained via the accumulation of both tangible (explicit) and intangible (tacit) knowledge (Nelson, 2005). The number of patents reflects only the "explicit" side of innovation but it says nothing about "tacit" knowledge (Sweet & Maggio, 2015). Moreover, some patents are never translated into commercially valuable products. Thus, the number of patents reflects inventions rather than innovation. It follows from these arguments that using conventional measures of innovation may be subject to measurement errors bias.

Considering these drawbacks, this paper attempts to capture cross-country differences in innovation by using the economic complexity index (*ECI*), developed by Hidalgo and Hausmann (2009). Innovative activities generally take the form of creating new products, services, and processes. National innovative capacity critically hinges on the stock of "*tacit*"

and "*explicit*" knowledge available within a country. For this reason, innovation can be directly inferred from the availability of productive capabilities embedded in an economy and its ability to assimilate and exploit existing knowledge. Building upon these ideas, Hidalgo and Hausmann (2009) develop *ECI* in which the accumulation of productive capabilities can be measured by examining the types of products a country produces (and exports).

More specifically, the construction of *ECI* relies on the "*diversity*" and "*ubiquity*" of a country's export bundles. *First*, ***diversity*** captures the number of products a country can produce. The central idea holds that a country is endowed with a larger set of productive capabilities if it can make a diverse range of products. Moreover, product diversification reflects the ability to assimilate and utilize innovative capabilities to create commercially valuable products, which is relevant for technological progress and economic growth. *Second*, ***ubiquity*** reflects product sophistication as it measures whether a country's products are popularly produced in many other economies. Low-ubiquity products (e.g., smartphones, machinery, chemicals and metals), which require many hard-to-find innovative capabilities, are generally produced only in a few economies possessing these capabilities (Felipe *et al.*, 2012). This is because the production of sophisticated products is viable only in places where prerequisite technologies and knowledge are available. Ubiquitous products (e.g., agricultural, wood, raw materials and commodities, and textiles), can be easily produced as they require much fewer productive capabilities (Felipe *et al.*, 2012). For example, Japan, Germany and the US, among others, are the most complex economies in the world because they can produce a diverse range of low-ubiquity products, such as medical imaging and machinery (Felipe *et al.*, 2012). Meanwhile, Cambodia, Papua New Guinea, and Nigeria are relatively technologically backward because they mainly produce ubiquitous commodities (Felipe *et al.*, 2012). Figure 2 depicts cross-country differences in innovation captured by *ECI*.

Recent studies employ *ECI* to capture the variation in innovative capabilities across the world. They establish that *ECI* is a key determinant of a wide range of economic outcomes. For instance, there exists evidence that countries with higher values of *ECI* experience higher rates of economic growth (Hidalgo & Hausmann, 2009; Zhu & Li, 2017), less income inequality (Hartmann *et al.*, 2017; Lee & Vu, 2020), better health outcomes (Vu, 2020), inclusive institutions (Vu, 2019), and increased labor share (Arif, 2021). Table 2 contains an overview of empirical studies related to economic complexity. Given that *ECI* directly matters for economic prosperity, this paper investigates the contribution of LGBT inclusion to national innovative capacity captured by *ECI*.

4. Results

4.1. Baseline estimates

Figure 3 illustrates the partial effects of LGBT inclusion on innovation. Consistent with the main hypothesis, the social inclusion of LGBT people is positively correlated with national innovative capabilities, holding other things constant. It suggests that countries with better legal rights and protections afforded to homosexual people are associated with higher levels of economic complexity, which reflects an enhanced capacity to innovate.

Table 3 presents OLS estimates of the effects of *LGBT* on *ECI*. In column (1), I report the unconditional estimates. Accordingly, the coefficient on *LGBT* is positive and statistically significant at the 1% level, which lends support to the central hypothesis articulated in Section 2. From columns (2) to (5), I gradually incorporate each of the main control variables in the regression. These factors are key drivers of national innovative capacity. Controlling for these country-level characteristics helps mitigate a major concern of omitted variables bias. The results demonstrate that the estimated coefficients on *LGBT* remain positive and statistically significant at the 1% level after ruling out the impacts of potentially confounding factors (Table 3). More specifically, a one-unit increase in *LGBT* is associated with a 0.32-unit increase in *ECI*, approximately one third of a standard deviation of *ECI* (column 5, Table 3). This reveals that the social inclusion of homosexual people exerts an economically significant influence on national innovative capacity.

Overall, the main findings suggest that improvements in legal rights and protections afforded to LGBT people play an important role in fostering innovation, *ceteris paribus*. A possible explanation is that the social inclusion of homosexual people helps spur technological innovation through fostering the quality of human capital. By contrast, countries characterized by discrimination against the LGBT community may suffer from lower levels of human capital accumulation, potentially leading to less innovation. The results extend the empirical analysis of Badgett *et al.* (2019) by documenting a potential channel through which the social inclusion of LGBT people transmits to income differences across the world. Furthermore, the current research contributes to an emerging line of research examining the contribution of economic complexity to economic performance (Table 2). In particular, fostering economic complexity arguably requires some attention to LGBT inclusion.

Trade openness is expected to facilitate the cross-border diffusion of knowledge and technologies, which may foster technological innovation. This paper, however, finds that the effects of trade liberalization on innovative capacity are statistically insignificant at

conventional thresholds (Table 3). Therefore, I do not find evidence supporting the argument that trade is an important driver of innovation. By contrast, the effects of financial development, government size, and population on *ECI* are positive and statistically significant at conventionally accepted levels (Table 3). These findings are consistent with previous studies (e.g., Hsu *et al.*, 2014; Sweet & Maggio, 2015; Vu, 2019).

4.2. Controlling for other effects

To avoid obtaining spurious estimates, I replicate the main results by accounting for numerous potential confounders, and report the results in Table 4. The online Appendix contains a detail description of additional controls.

First, I control for the effects of the diversity of birthplaces of immigrants. This is motivated by recent studies linking birthplace diversity and economic development (Alesina *et al.*, 2016; Bahar *et al.*, 2020). In particular, Bahar *et al.* (2020) find that an index of population diversity is positively correlated with *ECI*. It is argued that countries with greater social tolerance toward LGBT people would attract immigrants, thus enhancing population diversity. Nevertheless, my findings are robust to accounting for these effects (Table 4). In contrast to Bahar *et al.* (2020), the effects of birthplace diversity on *ECI* are imprecisely estimated at conventional levels of significance. This suggests that social tolerance toward LGBT people plays a more prominent role in shaping national innovative capabilities. *Second*, I incorporate dummy variables for legal origins in the regression. The basic idea is that common-law countries endowed with greater protection of private property rights are arguably more innovative. The baseline estimates, however, are insensitive to performing this empirical exercise. *Third*, I control for the effects of land suitability and resource endowments because these factors may affect technology-intensive industries, following Vu (2019). The inclusion of these controls in the benchmark model fails to alter the main results. *Finally*, my results may yield a spurious relationship between the social inclusion of LGBT people and innovation if I fail to control for the quality of institutions and income levels as highlighted earlier. For this reason, I incorporate the measures of democracy, institutional quality, and income per capita in Table 4. Accordingly, the estimated coefficients of *LGBT* are still positive and statistically significant at the 1% level. When all of these additional control variables are included in the regression, the impacts of the social tolerance toward homosexuality remain precisely estimated at conventional levels of statistical significance (Table 4). Overall, I find that the baseline findings are robust to controlling for numerous potentially confounding factors.

4.3. Additional robustness checks

To provide a valid basis for causal inference, this paper performs other sensitivity checks. The results and detailed discussions of additional robustness analyses are provided in the online Appendix to conserve space.

First, the study rules out the possibility that the positive relationship between LGBT inclusion and innovation across countries is exclusively driven by the inclusion of specific groups of countries. To this end, I exclude countries located in the same continent because they may share common cultures, histories and geographic characteristics. Moreover, countries whose values of the *LGBT* index equal zero are removed from the sample. The inclusion of continent dummies also accounts for unobserved heterogeneity across regions that may affect innovation and the social inclusion of homosexual people. As shown in the online Appendix Table A3, the results remain intact. Hence, the main findings are unlikely to be purely proxies for the inclusion of specific categories of countries or unobserved region-specific factors.

Second, a concern relates to the role of cultural factors in shaping technological innovation and social tolerance toward homosexual acts. For example, individualistic cultures may drive innovation by affecting the institutional environment (Gorodnichenko & Roland, 2017). Collectivistic societies tend to punish those deviating from norms and standards, and emphasize conformity. Hence, it may spur the social exclusion of the LGBT community. To address this issue, I allow several proxies for the cross-country variation in cultural dimensions to enter the benchmark model specification. These additional controls include social trust, the cultural dimension of individualism/collectivism, and the fractions of the population practicing major religions. The results reported in the online Appendix Table A4 indicate that my findings are not purely driven by cultural factors.

Third, I check for potential bias induced by constructing a simple average of *LGBT* across the period 1966 – 2011. It is important to re-emphasize that the social inclusion of LGBT people exhibits little variation across the years within a country. Hence, the use of an average *LGBT* is relevant in this context. However, one may well argue that the baseline estimates may be driven by the period chosen to compute *LGBT*. Therefore, I replicate the benchmark results by using the main variable of interest computed in different years. The results indicate that the coefficients on *LGBT* retain their signs and significance levels (the online Appendix Table A5). Furthermore, the use of alternative measures of national innovative capacity fails to alter the core findings (the online Appendix Table A6).

Finally, the paper checks for robustness to spatial dependence. The underlying idea is that innovative capabilities and social tolerance toward homosexuality may transcend borders due to the international diffusion of knowledge and technologies, and socio-economic interactions. The presence of such relationships between countries may lead to inconsistent estimates. To mitigate this concern, I calculate the standard errors that correct for spatial dependence (the online Appendix Table A7).[3] Additionally, it is evident from the online Appendix Table A8 that my findings are unlikely to be exclusively driven by potential outliers.

5. Further analyses

5.1. Individual-level analysis

The cross-country evidence provides suggestive evidence of a positive link between LGBT inclusion and national innovative capabilities. Although I attempt to control for numerous confounding factors, a key threat to identification relates to the effects of unobserved country-specific factors. Given that the findings are drawn from a cross-country framework, it is impossible to rule out this possibility using country fixed effects (FEs). This motivates an analysis at the subnational level. Unfortunately, there exists no comprehensive dataset of both LGBT inclusion and innovation at the region level across the globe. Moreover, the construction of such data would be very challenging. Therefore, I employ data from the World Values Survey to explore the relationship between respondents' attitudes toward homosexuality and technological innovation (Table 5).

The paper uses data conducted from face-to-face interviews across countries over six waves from 1981 to 2014. The main proxy for LGBT inclusion is derived from a question in which respondents are asked about the extent to which they think homosexuality is justifiable. Higher values correspond to greater tolerance toward homosexual behaviors. I adopt seven questions reflecting people's attitudes toward science and technology, and new ideas, taking risks and changes as dependent variables. Furthermore, individual-level controls are incorporated in all regressions, including age, age squared, income levels, dummy variables for male, social trust and educational attainment. Country dummies are added to all regressions to control for unobserved country-specific factors. I further include religion and wave FEs in all models. The online Appendix contains a detailed description of these variables.

[3] See Vu (2021) for an application of this method within a cross-country framework.

Table 5 reports the estimation results from the individual-level analysis. Accordingly, the estimated coefficients of *Homosexuality* are statistically significant at the 1% level except in column (6). The positive sign of the coefficients is in line with the cross-country evidence that the social inclusion of LGBT individuals helps promote technological innovation. The dependent variable used in column (1) is whether survey participants agree that we depend too much on science versus faith (*E220*). The answers are coded from one to ten with higher values corresponding to negative views about science and technology. For ease of interpretation, I recode this variable by multiplying it by minus one, so that higher values represent positive attitudes toward technological advances. The second question is whether respondents agree that science and technology are changing our life too fast (*E219*). Higher values imply negative views about technological progress. I also recode this question so that higher values denote positive views about technological changes (column 2). The next question is whether respondents think our world is better off because of science and technology (column 3). As evident in columns (1) to (3), social tolerance toward homosexual acts is positively associated with attitudes toward science and technology.

The remaining columns of Table 5 present empirical estimates of the effects of homosexuality on respondents' views about new ideas, taking risks and changes. In column (4), the dependent variable is whether survey participants agree that new ideas are better than old ones (*E046*). Furthermore, I use the question about attitudes toward the importance of new ideas and creativity (*A189*). The answers are also coded from one to ten with higher values corresponding to greater disagreements with this viewpoint. I also recode this variable by multiplying it by minus one to make it easy to interpret the findings. Next, I use the question in which respondents are asked whether they welcome or worry about changes in column (6) (*E047*). An increase in this variable is associated with positive views about changes. The final dependent variable adopted in column (7) is whether survey participants disagree about the importance of taking risks and adventure (*A195*). For ease of interpretation, this variable is also re-calculated by multiplying it by minus one. The estimated coefficients of *Homosexuality* are statistically significant at the 1% level when different dependent variables are used (except in column 6). Taken altogether, my findings suggest that the social inclusion of homosexual people is linked to people's positive attitudes toward new ideas, creativity, changes, adventure and taking risks.

Overall, the individual-level analysis reveals that people who self-report tolerance toward homosexuality tend to have positive attitudes toward technological progress. The effects of

Homosexuality on innovation remain precisely estimated at conventional levels of statistical significance after accounting for a wide range of possible confounders, including individuals' characteristics, unobserved country- and time-specific factors. The inclusion of religion dummies helps address a concern that my findings just proxy for other cultural and religious factors. Therefore, the subnational evidence lends further support to the baseline findings.

5.2. Potential channels of transmission

The central hypothesis rests upon the premise that the social inclusion of LGBT people helps improve the quality of human capital (Section 2). Furthermore, LGBT-supportive policies may signal low barriers to inflows of human capital. These factors enhance national innovative capacity. The cross-country OLS estimates lend support to the main hypothesis. This section provides some further evidence on a key mechanism underlying the relationship between LGBT inclusion and innovation.

To this end, the study replicates the benchmark estimates by controlling for different measures of human capital (Panel A, Table 6). It is evident from Table 6 that the effects of LGBT inclusion on innovation remain precisely estimated at the 1% level of significance. Importantly, the magnitude of the estimated coefficients reduces significantly when the proposed channel of influence is incorporated in the regression. For instance, the results in column (1) of Panel A indicate that the baseline estimates decrease to nearly a half when I control for the human capital index. This suggests that the effects of LGBT inclusion on national innovative capacity are partially mediated by the accumulation of human capital.

Next, different measures of human capital are regressed on *LGBT* (Panel B, Table 6). Following Kraay (2019), I employ the World Bank's human capital index in column (1). This indicator captures the expected human capital that a child born today may obtain by the age of 18, considering any risks associated with poor health and education prevailing in his/her country (Kraay, 2019). In column (2), I estimate the effects of the social inclusion of homosexual people on years of schooling. Hanushek and Woessmann (2012) demonstrate that a measure of cognitive skills performs better than the years of schooling when it comes to predicting comparative development across countries. For this reason, I adopt an index of cognitive abilities as the dependent variable in column (3). In the last column, I use an index of national IQs (intelligence) obtained from Lynn and Meisenberg (2010). This metric captures the cross-country variation in cognitive attainment, which is highly correlated with educational attainment (Lynn & Meisenberg, 2010). Using different proxies for human capital skills, I find

that the social inclusion of LGBT individuals is positively associated with human capital accumulation. This lends support to the proposition that LGBT inclusion affects innovation through enhancing the quality of human capital.

The effects of LGBT inclusion on the quality of human capital also remain robust to controlling for various confounding factors (the online Appendix Table A9). This empirical exercise is similar to that in Table 4. It is important to note that LGBT-supportive policies may affect the innovation process through other channels such as national creativity. However, a major challenge with exploring other potential mechanisms stems from the availability of comparable data across the world. Thus, a potential avenue of future research is to examine other channels of transmission that would help advance our understanding of the relationship between social tolerance toward LGBT individuals and innovation.

6. Conclusion

It is widely acknowledged that gender disparities in many aspects of empowerment and well-being (e.g., education, health and employment opportunities) are detrimental to economic growth and development (Knowles *et al.*, 2002; Duflo, 2012). Nevertheless, the degree to which discrimination against LGBT people affects economic performance has received scant attention among economists. This is surprising given a growing interest in promoting the social inclusion of LGBT and/or other marginalized groups in many parts of the world. To the extent fostering social inclusiveness of the LGBT community contributes to enhancing social justice and economic development, we need to obtain a better understanding of these relationships.

This paper builds upon a recent study by Badgett *et al.* (2019) that proposes an index of LGBT inclusion for a large number of countries. They document a positive relationship between LGBT inclusion and income per capita using a world sample of countries. This paper postulates that legal rights and protections afforded to homosexual people play an important role in fostering national innovative capacity, which is a key driver of sustained growth. To test this proposition, I carry out empirical analysis at the global and subnational levels. I also employ *ECI* as a novel measure of innovation to address several concerns associated with conventional innovation metrics. The baseline results obtained from estimating cross-country OLS models lend credence to a positive link between LGBT inclusion and innovation. Additionally, the main findings withstand a wide range of robustness analyses.

To rule out the possibility that the cross-country evidence is confounded by unobserved country-specific factors, the study performs an individual-level analysis using data from the

World Values Survey. The subnational evidence reveals that survey respondents who self-report tolerance toward homosexual acts have positive attitudes toward science and technology, new ideas and creativity, adventure and taking risks, and changes. The results are insensitive to accounting for a variety of individual- and country-level characteristics. Having established a positive link between the social inclusion of LGBT people and national innovative capacity, this paper examines a key mechanism behind this relationship. It provides suggestive evidence that LGBT inclusion exerts a positive influence on the accumulation human capital, which acts as a catalyst for innovation.

To conclude, this research documents strong and robust effects of LGBT inclusion on innovation. Nevertheless, my findings by no means suggest that cross-country differences in innovative capacity are fully attributable to attitudes toward homosexuality. Instead, the results imply that reducing discrimination against LGBT people, at least partially, contributes to economic prosperity through strengthening innovation. Therefore, formulating development strategies aiming at inclusive growth should not ignore the social inclusion of marginalized groups, including LGBT people.

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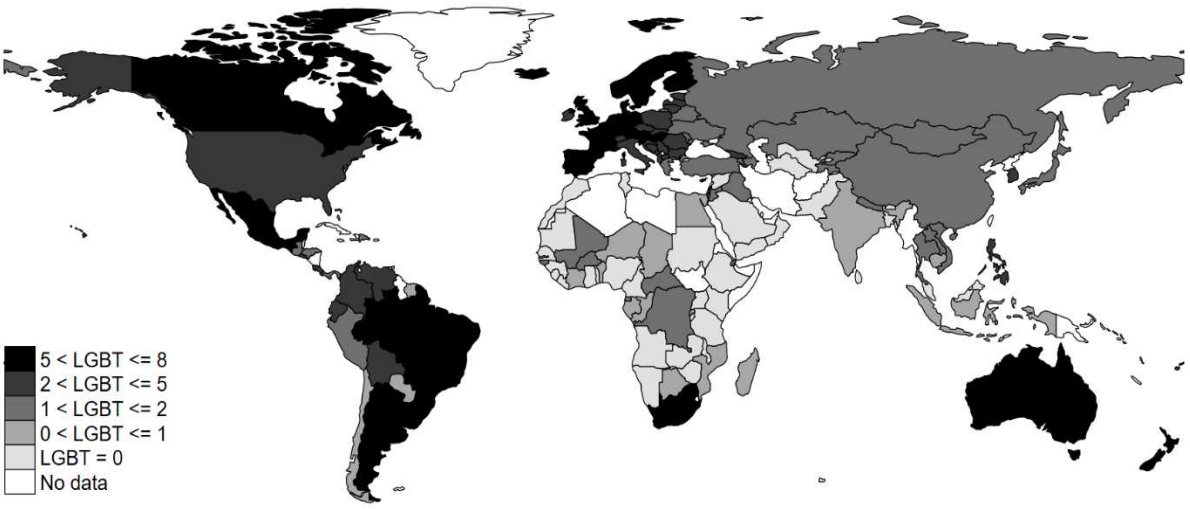

Figure 1. The worldwide distribution of LGBT inclusion

Notes: This figure depicts international variation in the social inclusion of LGBT people. Higher values correspond to better legal rights and protections afforded to homosexual individuals. See also Table 1.

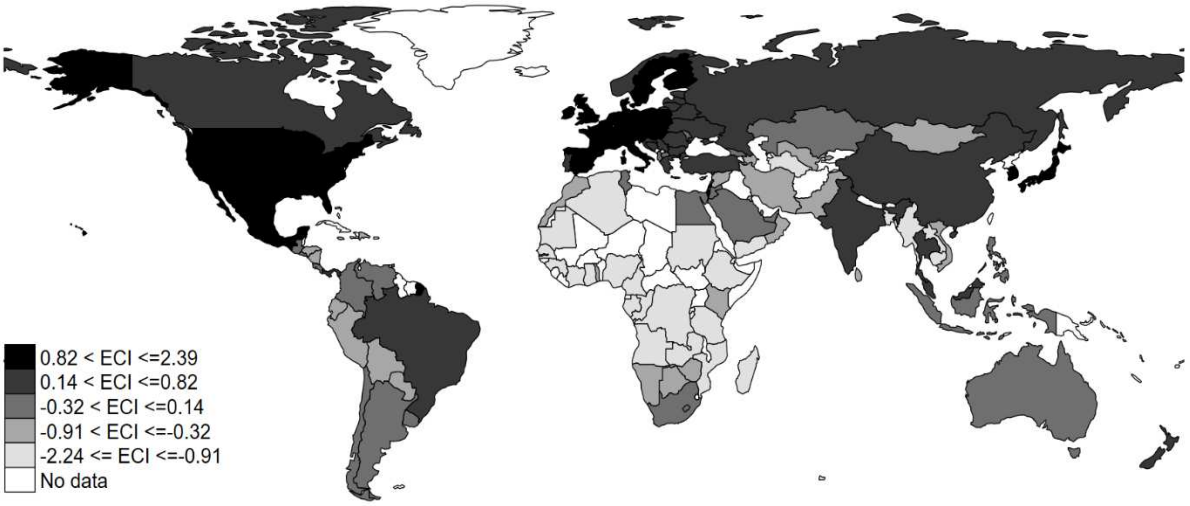

Figure 2. The worldwide distribution of innovation

Notes: This figure depicts international variation in national innovative capacity measured by the economic complexity index. Darker areas denote countries endowed with more innovative capabilities. See also Table 1.

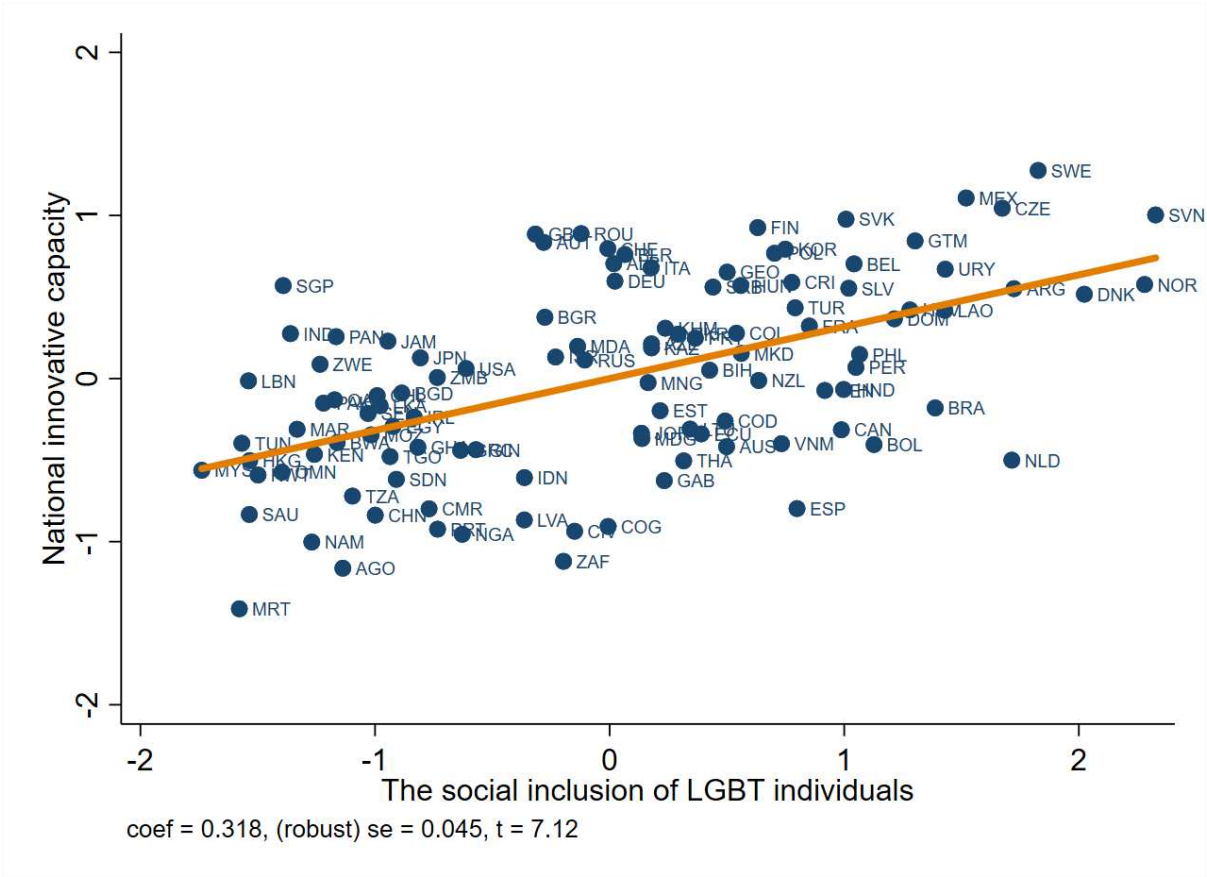

Figure 3. The partial effects of LGBT inclusion on innovation

Notes: This figure depicts the partial effects of the social inclusion of LGBT people on national innovative capacity, captured by the economic complexity index. The results are based on the benchmark estimates reported in column (5) of Table 3. Countries' abbreviations are obtained from the World Bank's World Development Indicators. See also the notes to Figures 1 and 2.

Table 1. Descriptive statistics and definition of key variables

Variable	Definition	Mean	Std.
LGBT	This index reflects cross-country differences in the social inclusion of LGBT people, captured by legal rights and protections afforded to homosexual individuals. *Source*: the Global Index on Legal Recognition of Homosexual Orientation developed by Badgett *et al.* (2019).	1.36	1.15
ECI	The economic complexity index. It reflects the availability of productive (innovative) capabilities that allow an economy to produce more sophisticated (high-productivity) products. This is a novel measure of cross-country differences in national innovative capacity. *Source*: the Observatory of Economic Complexity.	0.02	0.93
Trade	An index of trade openness, measured by the values of exports and imports as a proportion of total GDP. *Source*: the World Bank's World Development Indicators.	827.18	3481.14
Finance	A measure of cross-country differences in financial development. This index is captured by domestic credit to private sector as a proportion of total GDP. *Source*: the World Bank's World Development Indicators.	41.53	33.71
Gov_size	This index reflects the size of the government, measured by government expenditure as a proportion of total GDP. *Source*: the World Bank's World Development Indicators.	15.32	4.89
Pop_size	The log of the size of a country's population. *Source*: the World Bank's World Development Indicators.	16.22	1.41

Notes: This table contains a description of key variables included in the benchmark model. To conserve space, I present detailed discussions of all variables and data sources in the online Appendix.

Table 2. Empirical studies using the economic complexity index

Study	Key findings
Hidalgo and Hausmann (2009)	This paper develops the method of reflections to construct *ECI*, and documents evidence of the positive effects of economic complexity on economic growth across countries.
Zhu and Li (2017)	Exploiting a world sample of countries, this paper revisits the link between economic complexity and economic growth. Their findings are consistent with Hidalgo and Hausmann (2009). Furthermore, this study reveals that the effects of economic complexity on economic growth are larger in countries endowed with better human capital.
Hartmann et al. (2017)	This paper examines the relationship between economic complexity and income inequality across countries. The authors indicate that complex economies tend enjoy an equal distribution of income, holding everything else constant.
Vu (2019)	This paper investigates the extent to which institutional quality helps foster economic complexity. The author provides suggestive evidence of a positive relationship between economic complexity and the quality of institutions across countries. This is closely related to the current research that attempts to uncover the determinants of economic complexity, which is the main measure of national innovative capabilities.
Lee and Vu (2020)	This paper argues that the distributional effects of economic complexity are reinforced by the quality of human capital.
Vu (2020)	This study goes beyond the existing literature by investigating the association between economic complexity and national health status. Using cross-country data, the author documents robust evidence of the positive impacts of economic complexity on different measures of population health. Accordingly, more complexity economies tend to enjoy better health outcomes arguably due to increased employment opportunities.
Arif (2021)	A recent empirical analysis by Arif (2021) reveals that economic complexity helps improve labour share via increasing the bargaining power of workers.

Notes: This table provides a brief review of selected empirical studies using the economic complexity index, which is a novel measure of national innovative capacity. See also the main text.

Table 3. LGBT inclusion and national innovative capacity, OLS estimates

Dep_var: ECI	(1)	(2)	(3)	(4)	(5)
LGBT	**0.543*** **	**0.539*** **	**0.354*** **	**0.330*** **	**0.318*** **
	[0.047]	[0.048]	[0.046]	[0.044]	[0.045]
Trade		0.001	-0.001	-0.001	-0.001
		[0.002]	[0.001]	[0.001]	[0.001]
Finance			1.491***	1.413***	1.378***
			[0.190]	[0.182]	[0.184]
Gov_size				0.038***	0.046***
				[0.010]	[0.011]
Pop_size					0.070*
					[0.039]
Observations (# of countries)	116	114	112	110	110
R-squared	0.448	0.443	0.675	0.712	0.721

Notes: This table presents OLS estimates of the effects of LGBT inclusion on national innovative capacity across countries. An intercept, omitted for brevity, is included in all regressions. See Table 1 for variables' description. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Robustness to controlling for other effects

Dep_var: ECI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LGBT	**0.306*** **	**0.309*** **	**0.290*** **	**0.318*** **	**0.283*** **	**0.238*** **	**0.243*** **	**0.114***
	[0.047]	[0.056]	[0.050]	[0.044]	[0.048]	[0.043]	[0.052]	[0.061]
Birthplace diversity	-0.337							-0.506
	[0.308]							[0.315]
Common law		0.018						-0.176
		[0.149]						[0.131]
Mixed law		-0.250						-0.078
		[0.176]						[0.172]
Land suitability			0.857***					0.832***
			[0.190]					[0.183]
Fuel exports				-0.002				-0.001
				[0.001]				[0.002]
Polity2 index					0.020**			-0.012
					[0.009]			[0.011]
Institutional quality						0.391***		0.338***
						[0.102]		[0.124]
GDP per capita (log)							0.197***	0.172**
							[0.060]	[0.078]
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations (# of countries)	109	106	103	110	106	110	110	103
R-squared	0.725	0.727	0.773	0.728	0.732	0.769	0.752	0.835

Notes: This table replicates the main results by accounting for other effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Individual-level evidence

	Attitudes toward science and technology			Attitudes toward new ideas, taking risks and changes			
Dep_var	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	E220	*E219*	*E234*	*E046*	*A189*	*E047*	*A195*
Homosexuality	**0.055*** **	**0.022*** **	**0.015*** **	**0.035*** **	**0.012*** **	**0.016**	**0.015*** **
	[0.003]	[0.005]	[0.003]	[0.004]	[0.002]	[0.025]	[0.002]
Male	-0.080***	-0.063***	-0.152***	-0.114***	-0.113***	-0.087	-0.347***
	[0.016]	[0.022]	[0.014]	[0.021]	[0.007]	[0.086]	[0.008]
Age	0.009***	-0.011***	-0.011***	-0.030***	-0.007***	-0.035**	-0.040***
	[0.003]	[0.004]	[0.002]	[0.004]	[0.001]	[0.016]	[0.001]
Age squared	-0.000***	0.000**	0.000***	0.000***	0.000	0.000	0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Income	-0.000	0.000	0.084***	0.027***	0.031***	0.082***	0.033***
	[0.004]	[0.005]	[0.004]	[0.005]	[0.002]	[0.020]	[0.002]
Education (upper)	0.023	-0.111***	0.263***	-0.064**	0.359***	0.740***	0.117***
	[0.025]	[0.034]	[0.021]	[0.032]	[0.012]	[0.142]	[0.013]
Education (middle)	-0.031	-0.164***	0.191***	0.054*	0.134***	0.477***	0.041***
	[0.021]	[0.028]	[0.018]	[0.028]	[0.010]	[0.143]	[0.011]
Social trust	0.141***	0.076***	0.146***	0.051**	0.053***	0.178*	0.105***
	[0.020]	[0.027]	[0.016]	[0.024]	[0.009]	[0.099]	[0.010]
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	113,780	44,842	117,140	72,118	119,982	5,239	119,800
R-squared	0.127	0.101	0.096	0.127	0.117	0.057	0.160
# of countries	72	43	73	52	75	4	75

Notes: This table reports empirical estimates of the relationship between LGBT inclusion and innovation at the individual level, using data from the World Values Survey. Respondents whose answers are coded as "don't know", "no answer", "missing, unknown", "not asked in survey" and "not applicable" are excluded from the sample. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. See also the main text and the online Appendix for detailed descriptions of variables.

Table 6. A mechanism analysis

	(1)	(2)	(3)	(4)
Panel A. LGBT inclusion and innovation, controlling for the quality of human capital				
LGBT	**0.173*** **	**0.207*** **	**0.210*** **	**0.226*** **
	[0.041]	[0.047]	[0.046]	[0.059]
Human capital index	3.089***			
	[0.398]			
Years of schooling		0.129***		
		[0.025]		
Cognitive abilities			0.580***	
			[0.102]	
National IQs				0.031***
				[0.007]
Baseline controls	Yes	Yes	Yes	Yes
Observations	107	95	65	80
R-squared	0.817	0.778	0.729	0.750

Panel B. The effects of LGBT inclusion on the quality of human capital

	(1)	(2)	(3)	(4)
Dependent variable	Human capital index	Years of schooling	Cognitive abilities	National IQs
LGBT	**0.051*** **	**0.776*** **	**0.128** **	**3.668*** **
	[0.008]	[0.191]	[0.051]	[0.697]
Baseline controls	Yes	Yes	Yes	Yes
Observations	107	95	65	80
R-squared	0.631	0.503	0.429	0.513

Notes: This table presents evidence on a potential channel underlying the relationship between LGBT inclusion and innovation. Panel A replicates the main results by controlling for different measures of the quality of human capital – the proposed channel of influence. Panel B provides empirical estimates of the effects of LGBT inclusion on cross-country differences in human capital accumulation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. See also the online Appendix for detailed descriptions of variables.