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Title: The Puzzling Relationship between International Development and Gender Equity:

The Case of Postsecondary Education in STEM in Cambodia

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The Puzzling Relationship between International Development and Gender Equity: The Case of Postsecondary Education in STEM in Cambodia

Gender parity is traditionally associated with economic development and urbanization (Fiske, 2012; Weiss, Ramirez, & Tracy, 1976). Women earn bachelor's degrees at higher rates than men in most economically developed countries (DiPrete & Buchmann, 2013; OECD, 2013). Within these countries however, sex continues to stratify postsecondary majors and careers in science, technology, engineering, and mathematics (STEM) fields (Charles, 2011b; England, 2010). This has considerable implications for women's earnings (Bobbitt-Zeher, 2007; Carnevale, Strohl, & Melton, 2011). Intriguingly, STEM gender gaps appear narrower outside the U.S. and Europe, especially in less developed nations (Charles & Bradley, 2009; Fryer & Levitt, 2010).

Why might this be? Several hypotheses have been proposed, including culturally-specific beliefs and practices about gender, education, and careers (Charles & Bradley, 2002, 2009; Fryer & Levitt, 2010; Nosek, et al., 2009). However, the phenomenon is not well-studied beyond a few select measures on cross-national educational assessments (e.g., Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA)).[i] No studies prior to this one, to our knowledge, have analyzed variation in postsecondary STEM gender gaps *within* developing countries. Furthermore, given the rapid increase in higher education participation across the globe (Schofer & Meyer, 2005), there may be critical albeit insufficiently understood socioeconomic factors associated with women's differential participation in STEM fields.

This study aims to address these deficits by examining sex segregation in STEM within a rapidly developing, non-Western country: Cambodia. While women's rising postsecondary

achievements have been studied extensively, much remains unknown about the mechanisms influencing their share of global increases in STEM higher education (Ramirez & Wotipka, 2001). It seems then important to examine gender inequality from a non-Western, lower-income perspective (see Small, 2009). Using merged data from the Cambodian General Census and the Cambodian Ministry of Education, Youth, and Sport, this study examines how socioeconomic development shapes women's share of postsecondary enrollment in STEM fields.

Literature Review: Gender, Socioeconomic Development, and STEM

The relationship between development and gender equity in education has been assumed to be positive. However, recent research finds complications and argues for further research (Chisamya, DeJaeghere, Kendall, & Khan, 2012; Khurshid, 2017). Even within economically emergent nations, more and less developed regions can vary in surprising directions. In a multilevel analysis of grade 12 students in Ethiopia, girls were found to have greater opportunities and more positive outcomes compared to boys, all else being equal, in those regions with less economic development (Tesema & Braeken, 2018). While opportunity and freedoms tend to be associated with the West, this assumption seems to need revision. Bridging literature on higher education, gender, and development, the following sections review cross-national studies on STEM education inequality, the context of our case study, and the grounds for a comparative and international lens into this puzzle.

Cross-National Variation in STEM Sex Segregation

Gender differences in career aspirations and postsecondary majors have been investigated extensively in highly developed and mostly Western, non-communist, and democratic countries (Cech, 2013; DiPrete & Buchmann, 2013; England, 2005; Watt, Shapka, Morris, Durik, Keating,

& Eccles, 2012). Less is known about other contexts about sex segregation – inequality on the basis of biological sex. Charles and Bradley (2002) find horizontal sex segregation exists across nearly all countries (e.g., greater shares of men in engineering and greater shares of women in humanities). Yet a puzzling finding emerges in the few cross-national studies which include less industrialized nations: developing countries tend to have *narrower* gender gaps in mathematical and scientific achievement than those with higher levels of economic development and gender equity (Charles & Bradley, 2009; Fryer & Levitt, 2010).

Cross-national data on science achievement has concentrated on secondary rather than postsecondary education. Using the World Economic Forum gender gap index[ii] and 2003 TIMSS (fourth- and eighth-graders) and PISA (15 year-olds) data, Fryer and Levitt (2010) suggest the gap in mathematics achievement essentially disappears in some Muslim countries, despite lower gender equity scores on the index. Also drawing on TIMSS data and country-level predictors from other multi-national data sources, Penner (2008) identified smaller gender gaps in mathematics achievement among less developed countries. In a similar finding with 2006 PISA data across fifty countries, Sikora and Pokropek (2011) found wider gender gaps in aspirations for science careers among nations with high per capita income and a highly industrialized labor sector.

Complementing this work on secondary school gender differences, Charles and Bradley (2009) leveraged 1990s United Nations Educational, Scientific and Cultural Organization data on gender distribution by field of study among forty-four countries participating in TIMSS. They found sex segregation was most pronounced in advanced industrial economies. Related, research suggests gender stereotypes about career fields (see e.g., Cheryan & Plaut, 2010; Ridgeway, 2011; Spencer, Steele, & Quinn, 1999) may be stronger in more affluent countries, where

selecting careers and postsecondary specializations may be a form of gendered self-expression (Cech, 2013; Charles & Bradley, 2009). By contrast, the economic stakes of major choices may be higher in countries with emerging economies.

All together, these studies suggest developing countries may be more amenable to women entering STEM fields. With such limited and broad measures however, restricted to children and early adolescents, these studies do not enable us to directly examine postsecondary differences by gender. These cross-national studies demonstrate variation exists, but do not have means to examine these countries' socioeconomic contexts. What explains STEM sex segregation within a particular developing country, and what might that tell us about this phenomenon elsewhere? This study aims to address this question, using a case study of a nation notably distinct from those which predominate the research literature on STEM sex segregation.

Contextualizing Development, Gender, and Educational Opportunity

A rapidly developing Southeast Asian country, Cambodia has experienced surging higher education enrollments in recent years (Un & Sok, 2014). In 2012, 101 higher education institutions were active, up from fewer than 10 in the 1980s (Ministry of Education, 2013). This rise follows the 1970s genocide during which the Khmer Rouge regime systematically executed the educated class and forced mass movement to rural areas and agricultural activities (Ayres, 2000a; Booth, 2014; Chhinh & Dy, 2009). Thus, Cambodia's college students – one or more generations post-conflict – represent a major juncture. Recent postsecondary expansion has been supported by investment from non-governmental development organizations as well as the government, in efforts to increase national economic development and improve regional economic competiveness with higher-income neighbors (Chealy, 2009; Ministry of Education, 2013; Un & Sok, 2014; World Bank, 2010).

Socioeconomic shifts have accompanied this postsecondary boom. Despite recent peace and economic development, Cambodia is still widely considered one of the most impoverished countries in the world, ranking 140th in per capita Gross Domestic Product (GDP) in 2015 (International Monetary Fund, 2016), and tied for 143rd in the Human Development Index (United Nations Development Program, 2015). However, Cambodia's economy has grown rapidly in recent decades. Annual GDP growth has averaged 7.6 percent since 1995, and total urban population has increased by 75 percent between 1998 and 2015 (World Bank, 2016). Cambodia's growth has not been evenly distributed (World Bank, 2016). Rather, Cambodia's educational institutions and its most educated population remains concentrated in Phnom Penh (Goh & Bunnell, 2013; McGee, 1969), which fits the classic definition of a "primate city": (1) at least twice the size of the second largest city or (2) a larger population than both the second and third largest cities combined (Jefferson, 1939). As sex segregation seems to vary cross-nationally by socioeconomic development and gender equity, we may find similar variation on these indicators within this rapidly industrializing nation.

Notably, urbanization is generally positively associated with girls' and women's educational opportunities and achievement (Cohen, 2006; Zhi-fang, 2001). Even in rural areas, girls' participation in schooling increases in direct relationship with household access to key infrastructure resources, including energy and transportation (Huisman & Smits, 2009; Kanagawa & Nakata, 2008; World Bank, 2009). Water access matters as well, positively affecting Cambodian children's y health as well as their school attendance(Hunter, et al., 2014; Sommer, Ackatia-Armah, Connolly, & Smiles, 2015). Clean drinking water appears additionally important for the educational opportunities of girls and women, who tend to bear the responsibility of collecting and hauling drinking water for their families (Koolwal & van de

Walle, 2013; Watkins, 2006). Moreover, safe toilet access in homes and schools is associated with girls' continued educational enrollment (Nallari, 2015; Tilley, Bieri, & Kohler, 2013).

While Cambodian culture has tended to place limited attention on girls' success in academic endeavors (Ayres, 2000b; Booth, 2014; Derks, 2008), their access to higher education has substantially improved. Between 2006 and 2011, the UNESCO Gender Parity Index for tertiary education rose from .46 to .62 in Cambodia, on a scale of 0 to 1 (World Bank, 2016). The Cambodian government has campaigned to increase girls' school retention and the percentage of women in teaching (Booth, 2014; Sen, 2015). Further, multinational organizations have supported and offered scholarships for girls to attend school (Filmer & Schady, 2008; United Nations Women, 2015). Private universities have dominated the growth of the higher education market, as the demand for postsecondary education has outpaced the supply of public institutions (Sen & Ros, 2013). Altogether, Cambodian women's educational opportunities have increased, albeit to varying degrees within the country.

STEM Sex Segregation: Beyond Highly Developed Countries

Given the rise of university participation in less developed countries (Schofer & Meyer, 2005) and the global movement of women into the labor force (Diprete & Buchmann, 2006; Vincent-Lancrin, 2008), it is important to examine postsecondary sex segregation in distinct social contexts. This manuscript aims to provide a theoretically generative counterpoint to a line of inquiry based primarily on empirical studies of highly developed countries. The following research questions guided the selection of variables, analyses, and interpretation.

1. Does the gender gap in STEM and STEM-related majors vary within Cambodia?
2. To what extent do socioeconomic development indicators influence women's share of enrollment in STEM and STEM-related fields?

3. To what extent does gender equity influence women's enrollment in STEM and STEM-related fields?

Methodology

This manuscript focuses on the national-level statistics obtained and analyzed by the authors. We procured and merged data from Cambodia's Ministry of Education, Youth, and Sport (MoEYS) and the General Population Census of Cambodia 2008 (National Institute of Statistics, 2008).[iii] MoEYS data on educational enrollment characteristics were provided primarily in Khmer, the dominant language. These figures were translated and systematically cross-checked by Cambodian colleagues; further validity checks on these translations were conducted using publicly available information from institutional websites, MoEYS reports, and Google Translate. The institutional-level population data details aggregate enrollment among "female" students, all ("total") students, "scholarship" students, and tuition-paying ("paid") students, by institution, branch, and major for the 2011-2012 academic year.[iv]

After creating institutional-level variables from these MoEYS data, we merged in province-level statistics from the 2008 Census. While Cambodia has 24 provinces in total, our analysis focuses on those 18 provinces with universities in the MoEYS dataset (Figure 1). Out of the initial 114 branch campuses reporting, 27 were excluded because of incomplete and/or unverifiable information, institutional designation, and major type. To enhance the inclusion of recently opened universities and STEM programs, we focused our analyses on students enrolled in their first two years. The final analytic dataset describes the enrollment patterns of 98,751 first and second year Cambodian university students majoring in 683 fields at 83 campuses located in 18 provinces. Because these data include only institutional aggregates of student-level

information, our primary unit of analysis is the institution, with attention to clustered provincial-level effects.

[INSERT FIGURE 1]

Analysis Plan

There were three main phases to the analysis. First, we investigated the distributions of our variables at the institutional and provincial levels, to examine the relationships between women's share of majors and provincial-level economic and social conditions. Next, because of the higher density of campuses in the primate city Phnom Penh, we used sample mean *t*-tests to assess significant differences from other Cambodian provinces on key predictor and outcome variables. Finally, in a series of ordinary least squares regression analyses using clustered standard errors to adjust for potential clustering effects at the provincial-level, we estimated the proportion of women in specific STEM and STEM-related majors. These models included development indicators, at the household and province levels, including gender equity. We include additional controls for institutional characteristics.

The model specification is stated below, with "Major" representing alternately: STEM, Accounting, Information Technology, or Health. Operational definitions of these fields immediately follow.

$$OLS\ (Women's\ share\ of\ major) - represented\ in\ Table\ 3$$
$$= \beta_0 + \beta_1 Household\ Size + \beta_2 UrbanDensity + \beta_3 High\ Resources + u$$

$$OLS\ (Women's\ share\ of\ major) - represented\ in\ Table\ 4$$
$$= \beta_0 + \beta_1 Household\ Size + \beta_2 Urban\ Density + \beta_3 High\ Resources$$
$$+ \beta_4 Phnom\ Penh\ + \beta_5 Female\ Educational\ Access$$
$$+ \beta_6\ \%\ Women\ Enrolled\ in\ Postsecondary\ + \beta_7\ \%\ Women\ Employed$$
$$+ \beta_8\ \%\ Scholarship\ Students + \beta_9\ Private\ Institution + u$$

Dependent Variables: Women in STEM and STEM-Related Majors

Our primary dependent variable is women's share of STEM postsecondary majors. We divide the list of Cambodian majors reported in the data into two mutually exclusive categories, STEM and non-STEM (Table A1), using the U.S. National Center for Education Statistics definitions of STEM while recognizing some of these majors may have particular relevance to the burgeoning Cambodian economy as well as other rapidly developing economies (Ginder & Mason, 2011). *STEM* includes majors in the following clusters: agricultural and environmental sciences, biological sciences, engineering, health (including medical/dental), natural sciences, and information technology. *Non-STEM* includes majors in the following clusters: arts and humanities, business, civil service/professions, and social sciences. The complete list of STEM majors is given in Table A1; a list of all majors is available by request.

We also predict women's share of three specific STEM and STEM-related majors relevant for and common among developing countries: information technology (STEM), health (STEM), and accounting (STEM-related). Globally, *information technology (IT)* is a high growth field with widely noted gender inequality in Western countries (e.g., Frehill, Abreu, & Zippel, 2015). Here, *IT* corresponds to Cambodian majors including computer science, studies, or networking; IT or information technology (at times followed by "systems" or "for business," "for

management," etc.); and technology management. *Health* corresponds to the following majors: dentistry, medicine, nursing, medical technician, midwifery, and pharmacy. In addition to these two STEM majors, we also examined *accounting* as a STEM-related major, on account of its popularity in Cambodia and mathematically-intensive nature.

To analyze participation in these fields, we developed indicators calculating total and percentage share of enrollment by gender, scholarship status, and major (STEM, IT, health, and accounting), at the campus- and provincial-levels. Notably, we restrict our models to include only institutions where that field of study is available. Therefore, while our study includes 83 Cambodian higher education institutions in 18 provinces, only 12 provinces offer STEM degrees, 16 offer accounting, 11 offer information technology, and 5 offer health. We return to geographic inequality below as well as in the limitations of our study.

Independent Variables

To predict gendered participation in STEM and STEM-related fields, we measured the socioeconomic success of women within provinces and other indicators of socioeconomic variation across Cambodia. Predictor variables were strategically selected based on previous assertions that socioeconomic factors influence women's postsecondary degree field choices (Charles, 2011a; Charles & Bradley, 2009). These include gender equity in education and employment.

Socioeconomic indicators. Correlation matrices and factor analyses were used to select unbiased estimators of provincial socioeconomic development, using variables from the 2008 Cambodian Census. *Average household size* has been seen as an important factor influencing a family's relative investment in the education of a particular child (Buchmann & Hannum, 2001; Maralani, 2008). An *urban density* scale was developed using principle components analysis

(PCA); its constituent components are (a) population density (calculated as persons/km^2) and (b) urbanicity (percent urban population). Again using PCA, we created a *high resources* scale indicating mean levels of resource development and infrastructure access among provincial households. Its components include (a) a binary indicator for having an airport, as a measure of major transportation infrastructure, as well as (b) three measures of average household access to infrastructure and resources associated with economic development: lighting sources (generator, city, or both), cooking fuel (electricity or gas), and toilet facilities (sewer or septic tank). We also assessed the independent effect of a *Phnom Penh* location, comparing these campuses to those located in the rest of the country.

Gender equity indicators. Three variables serve as indicators of gender equity in each province. We used PCA to create a provincial *female educational access* indicator, which includes highly interrelated phenomena ($r >= .95$): (a) the percentage of women aged 25 years or older with postsecondary educational attainment, (b) female literacy rate (as percentage of population ages 15 and above), and (c) the average age at marriage for women. In addition, we control for the *percentage of females employed* in each province. This variable is measured by the proportion of economically active females, a metric commonly used to capture women's employment rates in developing countries (Fuse & Crenshaw, 2006; Jelin, 1977; Pillarisetti & McGillivray, 1998). From the MoEYS data, we also account for the provincial *percentage of women enrolled in postsecondary education (PSE)* (irrespective of degree field).

Institutional characteristics. Models include two educational institutional funding characteristics: *private institution* (reference group: public) and the *percentage of scholarship students* enrolled at each branch campus.

Triangulation

In addition to validity checks noted above, the authors conducted site visits, informational interviews, and collected other qualitative data at several Cambodian universities across multiple provinces. Those results are not presented in this manuscript in the interest of clarity, focus, and space limitations. However, the qualitative data informs our selection of dependent variables (majors). Notably, access to technology was limited, around the country and across institutional types. Accounting students hand-calculated figures in lined notebooks rather than using computing software or complex calculators. Even information technology programs tended to use older computers with limited internet access, such as the computer lab pictured in Figure 2, with six-year-old donated computers. Modern equipment was in high demand from university faculty and staff, from software to calculators, especially outside of the major cities.

[INSERT FIGURE 2]

Limitations

Our analysis is limited by the availability of covariates and controls, as well as sample size. Other than the small *n* inherent in studying institutional-level effects in a nation with an emerging postsecondary sector, one limitation of this study is a central assumption: that most Cambodian students attend college or university in their home province. The limited research on the migration patterns of Cambodian youth has focused on low-wage work rather than higher education and professional careers (Bylander, 2015a, 2015b). The authors consulted Cambodian reports and conducted informational interviews with social scientists and educational leaders in universities, centers, and MoEYS. These sources concurred that inter-provincial mobility tends to be restricted to a small percentage of highly talented and/or wealthy students, for the following reasons: (1) government scholarships tend not to include moving/boarding expenses and (2) the strongest students may leave Cambodia for competing offers and scholarships abroad (e.g.,

Vietnam, Thailand, outside of Asia). In sum, most Cambodian youth do not to have the economic mobility to attend postsecondary education outside their own province; those few who do often attend university outside the country. Future studies and data may further illuminate our findings.

Notably, Cambodia's enrollment data were aggregated at the institutional level; no student-level administrative data yet exists. Without individual student-level indicators we cannot draw conclusions about the identities of college students in Cambodia past the categories provided in the data: gender and scholarship status. Finally, we were not able to measure institutional prestige, a metric often used in higher education research, as a standardized ranking system has not yet been established. We created and considered an indicator for institutional prestige, established by the monarchy (institutions bearing the designation "Royal") or otherwise considered highly prestigious.[v] Unfortunately, all six of these institutions are in Phnom Penh; therefore, we excluded this variable from our final regression models.

Results

Within-Nation Variation in Socioeconomic Development and Gender Equity

Table 1 provides summary descriptive statistics for the 18 provinces in our sample. There is notable variation in the socioeconomic indicators, including the components of our standardized scales of urban density and high resources. Across provinces, urbanicity (percent urban) ranges from 1.7% to 93.6%, with a mean of 17.8%. The percentage of households with toilets ranges from 10.7% to 89.4%. Gender equity varies considerably as well. The literacy rate

for females over age 15 ranges from 36.6% to 90.6%; the average share of women enrolled in postsecondary education is 40.9% (range: 19.0% - 51.0%).

[INSERT TABLE 1]

Table A2 parses this aggregated information by province, underscoring the merit of examining variation *within* Cambodia. We consider the demographic characteristics of students participating in higher education in Cambodia in general, in comparison to student attributes as they vary by major field of study. Women's share of enrollees ranged as high as 50.0% in Kratié and 51.0% in Kampong Speu. Aside from these latter two provinces, men are steadily in the majority. Scholarship students' share of provincial postsecondary enrollment ranges from 0.0% in Koh Kong to 91.0% in Kampong Chhnang. Despite having the highest rate of women over age 25 with postsecondary education (2.1%), Phnom Penh has the fifth lowest postsecondary enrollment rate for women (37.0%) and falls in the middle of the provinces with respect to the scholarship student participation rate. While Phnom Penh's level of economic development conforms to the pattern on primate cities, the less urban provinces appear particularly conducive to the growth of women in higher education and especially in mathematical and science fields.

How Does the STEM Gender Gap Vary Across Provinces?

Table 2 shows enrollment differences between campuses in the capital (Phnom Penh) and all other provinces. Results show notable differences by gender, across all majors. Interestingly, the proportion of students on scholarship is lower in Phnom Penh (11.6%) than in other provinces (16.8%). Even more intriguing: women in provinces outside of Phnom Penh constitute a higher share of enrolled postsecondary students (41.0%) than those in the capital (37.2%). This pattern holds in part with our dependent variables as well: gender gaps in Cambodian students'

participation in STEM and STEM-related majors. Women comprise a greater share of STEM and IT majors outside Phnom Penh than they do inside Phnom Penh. Specifically, women represent 23.1% of traditional STEM majors in the provinces, as compared to 18.9% in Phnom Penh. Women's participation in IT majors is nearly three times higher in the provinces (18.4%) than in Phnom Penh (6.8%). Looking across these data, these figures further indicate how women's representation in STEM and STEM-related fields varies within this rapidly developing country. Building on these findings, we investigate potentially more nuanced dimensions to the relationship between development and women's participation in STEM and STEM-related fields.

[INSERT TABLE 2]

Does Socioeconomic Development Influence Women's Representation?

Table 3 reports on the first set of regression models. These estimate the degree to which women's participation in STEM majors is explained by urbanization (urban density) and provincial infrastructure access (high resources).[vi] While we find null effects for STEM and IT, development has significant effects on accounting and health. These figures suggest the importance of looking beyond the traditional "STEM" definition as a singularly relevant category for analysis.

[INSERT TABLE 3 HERE]

Socioeconomic development indicators predict women's share of accounting and health majors, in distinct directions. With each standard deviation increase in urban density, women's share of accounting majors rises 20.5% ($p < .05$). By contrast, women's share of accounting majors *decreases* 17.6% with each standard deviation increase in high resources ($p < .05$), that is when provincial households have greater access to modern household infrastructure. Women's share of accounting majors is positively related to urban density but negatively related to

resources. Next, we turn to health. Although our health sample is reduced to 58 institutions clustered in five provinces, our model predicting health explains 11% of the total variance in women's share of health majors. Urban density is a negative predictor, such that a one standard deviation increase is associated with a 23.2% decline in women's share of health majors ($p < .001$). Meanwhile, high resources positively predict women majoring in health; a one standard deviation increase in high resources is associated with an 18.0% *increase* in women's share ($p < .001$). In summary, we find urban density and high resources predict accounting and health, with near mirror opposite results.

To What Extent Does Gender Equity Explain Women's Representation?

Table 4 presents results from our final model, including indicators of provincial socioeconomic development and urbanization, provincial indicators of gender equity, and institutional characteristics. We also include a dichotomous indicator for Phnom Penh campus location. Overall, model results are stronger across all four outcomes.

[INSERT TABLE 4]

Turning first to STEM, there are three significant findings. First, a one standard deviation increase in urban density predicts a 25.7% rise in the share of women in STEM ($p < .05$), all else being equal. Women's representation in STEM majors is 5.2% smaller at private as compared to state-sponsored institutions. The third finding on women's share of STEM majors merits greater explanation. Our model predicts a 151.1% decline in women's share of STEM majors in Phnom Penh, the province with the greatest concentration of universities ($p < .05$). Recall these are linear estimates and therefore do not arbitrarily stop at women's share being zero. Rather, this indicates a powerful negative effect for being in the capital, independent of the other significant and non-significant predictors in the model. Table 2 showed Phnom Penh campuses had, on

average, significantly higher numbers of men in STEM and IT majors ($p < .01$) as well as higher shares – there were nearly three times fewer women in IT in Phnom Penh as compared to the other provinces. There were also visibly albeit not necessarily significantly lower numbers of women in STEM ($p < .10$) and IT majors. STEM is a heterogeneous cluster of fields. The following paragraphs detail the patterns observed for specific STEM and STEM-related majors.

Our estimates of women's share of IT majors are particularly intriguing and offer deeper potential explanations. Notably, the effects of our provincial economic, urbanization, and household indicators increase in strength as compared to the prior model (Table 3). In particular, a one standard deviation increase in urban density is associated with a 53.8% increase in women's share of IT majors ($p < .001$). A one standard deviation increase in high resources is associated with a 13.6% decrease in women's share. In other words, all else being equal, women are comparatively less represented in IT when provincial households have greater resource access. Conversely, women are better represented in IT in more densely populated and urbanized provinces. There is also an additional highly negative effect for being located in Phnom Penh ($p < .05$).

Turning to health and accounting, the models increase in strength ($r^2 = .15$ and .18, respectively). In the health model, a one standard deviation increase in resources raises women's share by 15.6% ($p < .01$). This finding should be interpreted with caution however, as we had to exclude multiple indicators in this small *n* model. Still, we find a negative relationship between the value of women's education and their representation among health majors: a one standard deviation increase is associated with a 21.3% decline in women's share, all else being equal. In the accounting model, which explains 18.0% of the variance in the share of women in accounting fields, a one standard deviation increase in household size is associated with a 39.7% decline in

women's share of accounting majors ($p < .05$). Notably, for every ten-point increase in the percent of scholarship students per branch, the share of women in accounting decreases 3.1% ($p < .05$).

Altogether, these results present a complex but consistent pattern. First, women are better represented in postsecondary education overall, and in postsecondary traditional STEM and IT majors, in universities outside of the primate city Phnom Penh. Women's representation in traditional STEM and IT is directly and positively related to urban density. By contrast, access to high resources has either a null or negative effect on women's share of STEM and STEM-related majors, with the exception of health, where the relationship is positive. In addition, while not consistently significant, the results reported in Table 4 identify an intriguing and primarily negative relationship between traditional gender equity measures and women's share of specific STEM and STEM-related majors. We explore these findings further in the paragraphs below.

Discussion and Conclusion

To our knowledge, this manuscript presents the first study of gender variation in STEM degree enrollments in a developing country. Using national and institutional data from one of the world's least affluent countries, our study examines within-nation variation in socioeconomic development and gender equity. As suggested by the title, the relationship between development and gender equity with respect to STEM fields is puzzling. We find distinct but primarily negative relationships between socioeconomic development indicators and women's representation in STEM and related majors. First, women's share of STEM and information technology (IT) majors is negatively associated with being located the capital Phnom Penh. This surprising finding defies conventional expectations that greater urbanization and resource access should be associated with higher educational outcomes for women (e.g., Cohen, 2006; Nallari,

2015).

Additional socioeconomic development findings are summarized below. Urban density has mixed effects on women's share of majors, including a negative relationship with accounting. In Table 4, urban density has a positive effect on women's share of STEM and IT majors. Access to high household and infrastructure resources negatively predict women's share of IT majors. Next, while the relationship between high resources and women's health share appears positive, this finding is complicated by limited covariates, as fewer provinces offer health degrees. Finally, the relationship between household size and women's share of majors is consistently negative, when significant and otherwise. Overall, these socioeconomic provincial differences suggest the importance of more in-depth case studies on the relationship between socioeconomic development and sex segregation in higher education.

With respect to gender equity, female educational access and higher provincial rates of well-educated and employed women are inversely associated with women's participation in health and information technology, critical fields for Cambodia's development goals. A recent study using familiar TIMSS data on eighth-graders reaches a complementary conclusion: perhaps through the gendering of career aspirations, nurtured via the Internet, sex segregation in STEM career aspirations is wider in affluent societies than in less affluent societies (Charles, 2017). Notably, recreational Internet access is generally unavailable (as noted in our methodology description) as well are other socializing media in Cambodia – at least outside of the upper and tourist/leisure classes, who reside in a limited number of provinces, including Phnom Penh. With respect to gender and economic equity, Phnom Penh, the capital city and university hub, has fewer women and scholarship students enrolled in its institutions, as compared to all other provinces with universities.

Should the search for female scientists shift away from its focus on the most socioeconomically developed provinces and countries? Our findings suggest globalization – occurring first in the major cities – might drive women away from STEM, implanting gendered ideologies where they did not previously exist. Cambodia and other less developed countries have rich and distinct cultural histories, including how gender functions as a social category. It seems a premature assumption to conclude differences are driven by encroaching global forces, especially given this is the first study of gendered postsecondary education pathways in this non-Western and industrializing country context. Future empirical work may shed further light on global variation in the gendering of mathematics and science, including how our narrative compares to other, distinct socio-cultural contexts. Recent work on Thailand's secondary school patterns (Lerdpornkulrat, Koul, & Sujivorakul, 2012) and personal communication with scholars from other Asian and Middle Eastern nations suggests considerable conceptual gains might arise from case studies of less developed countries. Importantly, research suggests the gender gap in STEM is malleable – historically, culturally, and socially (DiPrete & Buchmann, 2013; McDaniel, 2012).

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[i] Notably, in the least developed countries, mobilizing survey teams and paying fees to participate in such major assessments tends to be viewed as a less important or unfeasible investment of resources (Wagner, Babson, & Murphy, 2011)

[ii] The World Economic Forum Gender Gap index measures the gender gap across four categories: economic participation and opportunity, educational attainment (across educational levels as well as female: male literacy rates), political empowerment, and health and survival (Hausmann, Tyson, & Zahidi, 2010).

[iii] The first and second authors were assisted in pursuing these data through affiliations [with Cambodian center, blinded for peer review].

[iv] While institutional names and majors were exclusively in Khmer, the MoEYS data spreadsheet titles and headers were provided in both English and Khmer languages. The terms marked in quotation marks are those used as the headers in the English versions of the original data.

[v] These otherwise prestigious institutions that do not bear the "Royal" designation are Institut de Technologie du Cambodge and Paññāsāstra University of Cambodia.

[vi] The overall variance explained in this simple set of models is low, only as high as 11% in the health model and less in the other three models. Recall that this is a study of only 83 Cambodian institutions offering STEM or STEM-related majors. This limited statistical power makes significance harder to achieve.

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FIGURES

Figure 1: Number of Campuses By Province In Sample

ISO Province Code	Province Name:
KH-1	Banteay Meanchey
KH-2	Battambang
KH-3	Kampong Cham
KH-4	Kampong Chhnang
KH-5	Kampong Speu
KH-6	Kampong Thom
KH-7	Kampot
KH-8	Kandal
KH-9	Koh Kong
KH-10	Kratié
KH-11	Mondulkiri
KH-12	Phnom Penh
KH-13	Preah Vihear
KH-14	Prey Veng
KH-15	Pursat
KH-16	Ratanakiri
KH-17	Siem Reap
KH-18	Preah Sihanouk
KH-19	Stung Treng
KH-20	Svay Rieng
KH-21	Takéo
KH-22	Oddar Meanchey
KH-23	Kep
KH-24	Pailin

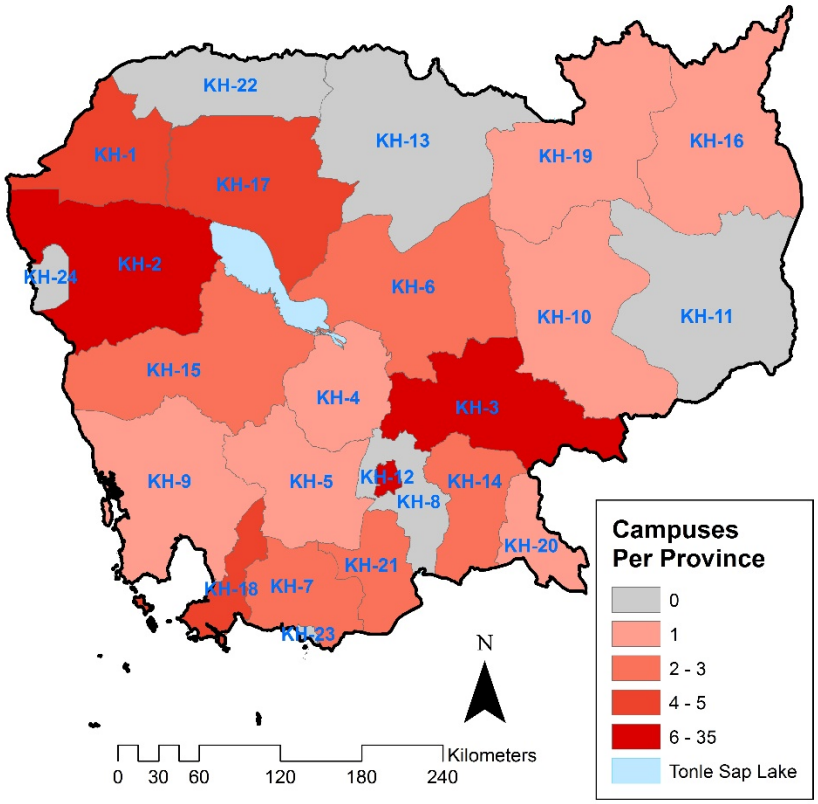

Figure 2. State University Computer Laboratory for Information Technology Students

Source. Photo by lead author, taken with permission while on a site visit with informants, 2013. Bars redact information identifying the university and donors, for confidentiality purposes.

Table 1. Descriptive Statistics Across Cambodian Provinces

	Mean	SD	Min	Max
Socioeconomic Development Indicators				
Average Household Size	4.73	0.30	4.20	5.40
Urban Density (*scale*)	-1.07	0.69	-1.39	1.63
Urbanicity	17.79	21.60	1.71	93.63
Population Density	286.01	813.30	9.30	3533.60
High Resources Scale (*scale*)	-1.62	1.10	-2.34	2.07
Airport in Province	0.17	0.38	0.00	1.00
Lighting Sources	25.12	21.87	7.61	94.76
Cooking Fuel	6.81	13.29	1.18	58.05
Toilet Facilities	25.14	18.64	10.65	89.38
Gender Equity Indicators				
Female Educational Access (*scale*)	-1.42	1.03	-3.59	1.94
% Females with PSE Above 25	0.20	0.49	0.04	2.14
% Literate Females Above Age 15	66.82	10.46	36.55	90.57
Average Age of Marriage for Women	22.77	1.11	20.70	26.30
% Females Employed	60.33	5.73	48.12	68.12
% Women Enrolled in PSE	40.89	7.63	19.00	51.00

Source. National Census of Cambodia 2008, province-level data.
Note. Sample limited to the 18 provinces in our analytic sample of provinces with universities: Banteay Meanchey, Battambang, Kampong Cham, Kampong Chhang, Kampong Speu, Kampong Thom, Kampot, Koh Kong, Kratie, Phnom Penh, Prey Veng, Pursat, Ratanakiri, Siem Reap, Preah Sihanouk, Stung Treng, Svay Rieng, and Takeo.

Table 2. Campus-Level Enrollment Differences Between Phnom Penh and Other Provinces

	Mean			Standard Error	
	Phnom Penh	All Other Provinces	Sig. Diff.	Phnom Penh	Other Provinces
Enrollment across Majors					
Female Students	776.11	233.60	**	191.17	41.87
Male Students	1310.63	336.38	***	280.96	59.28
% Female across Majors	***37.2%***	***41.0%***	***N(campuses)***	***35***	***48***
Financing					
Scholarship Students	241.34	95.69	**	59.71	17.90
Paid Students	1845.40	474.29	***	423.73	92.05
% Scholarship across Majors	***11.6%***	***16.8%***	***N(campuses)***	***35***	***48***
STEM and STEM-related Majors					
Female STEM Majors	83.97	25.39		39.48	9.54
Male STEM Majors	361.31	84.44	*	119.95	26.79
% Female in STEM (n=76)	***18.9%***	***23.1%***	***N(campuses)***	***35***	***41***
Female Accounting Majors	112.69	57.48		40.79	10.42
Male Accounting Majors	32.23	26.37		9.52	6.50
% Female in Accounting (n=81)	***77.8%***	***68.6%***		***35***	***46***
Female Health Majors	33.34	4.61		23.81	2.58
Male Health Majors	36.97	10.04		26.37	6.30
% Female in Health (n=58)	***47.4%***	***31.5%***		***35***	***23***
Female IT Majors	15.06	11.34		4.33	6.65
Male IT Majors	205.20	50.32	*	68.31	13.76
% Female in IT (n=73)	***6.8%***	***18.4%***		***35***	***38***

Source. Authors' analysis of Ministry of Education, Youth, and Sport national enrollment data for academic year 2011-2012.

Note. Mean enrollments by type across 83 campuses, 35 of which were in Phnom Penh and 48 of which were in the other provinces in our sample. Two-sample t-tests with equal variances were used to calculate statistical differences in mean enrollment numbers *(unless otherwise specified: n=83, df=81)*. + p<.10, * p <.05, ** p <.01, *** p<.001.

Table 3. Cambodian Women's Share of Enrollment in Specific Science Fields as Explained by Socioeconomic Indicators

	Percentage of Women in Specific Science Fields			
	STEM	Accounting	Information Technology	Health
Average Household Size	-10.89 (9.83)	-12.38 (16.91)	-2.60 (12.87)	-12.66 (6.48)
Urban Density Scale	-2.90 (6.70)	20.54* (9.40)	0.12 (3.75)	-23.22*** (0.88)
High Resources Scale	2.57 (5.08)	-17.59* (7.09)	-0.30 (2.94)	18.04*** (0.50)
Constant	63.03 (47.18)	103.36 (80.96)	19.39 (62.66)	65.760 (31.62)
N Institutions	76	81	73	58
N Provinces	12	16	11	5
R^2	0.02	0.07	0.01	0.11

Source. National Census of Cambodia 2008 and national enrollment data from Cambodia's Ministry of Education, Youth, and Sport, 2011-2012.

Note. Standard errors in parentheses, clustered at the province level. The total number of institutions in our analysis is 83. The number of observations varies for each model however because each model estimates women's share only among provinces which offer a degree in that field in at least one institution.

$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 4. Cambodian Women's Share of Enrollment in Specific STEM and STEM-related Fields, by Provincial and Institutional Indicators

	Percentage of Women in Specific Science Fields			
	STEM	Accounting	Information Technology	Health
Socioeconomic Indicators				
Average Household Size	-0.79	-39.65*	-10.72	-
	(15.65)	(16.62)	(14.03)	-
Urban Density Scale	25.71*	51.02	53.84***	-
	(10.89)	(40.36)	(10.65)	-
High Resources Scale	4.20	-14.20	-13.62***	15.56**
	(8.68)	(12.22)	(4.57)	(2.59)
Phnom Penh Campus	-151.14*	-34.666	-114.88*	-
	(68.16)	(107.33)	(49.23)	-
Gender Equity Indicators				
Female Educational Access Scale	24.91	-15.14	4.12	-21.34**
	(15.40)	(11.92)	(10.11)	(3.04)
Percentage of Women Enrolled in PSE	0.90	-0.28	-0.65	-0.87
	(1.03)	(0.94)	(0.51)	(0.53)
Percentage of Women Employed	2.10	-0.81	-0.03	-0.59
	(2.09)	(2.02)	(1.20)	(0.39)
Institutional Indicators				
Percentage of Scholarship Students	0.00	-0.31*	0.04	-0.00
	(0.04)	(0.14)	(0.03)	(0.09)
Private Institution (ref: public)	-5.15*	7.90	2.95	-7.00
	(2.02)	(8.85)	(1.71)	(4.31)
Constant	-74.82	215.11**	131.26	79.56***
	(197.16)	(169.75)	(119.41)	(6.89)
N Institutions	76	81	73	58
N Provinces	12	16	11	5
R^2	0.09	0.18	0.11	0.15

Note. Standard errors in parentheses, clustered at the province level. Our analytic sample is comprised of 83 institutions. The number of observations varies because each model estimates women's share only among provinces which offer a degree in that field in at least one institution. In our health model, household size, urban density, and Phnom Penh campus were excluded for multicollinearity. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.
Source. Data from Cambodian Ministry of Education, Youth, and Sport, 2011-2012.

APPENDIX

Figure A1. Population density

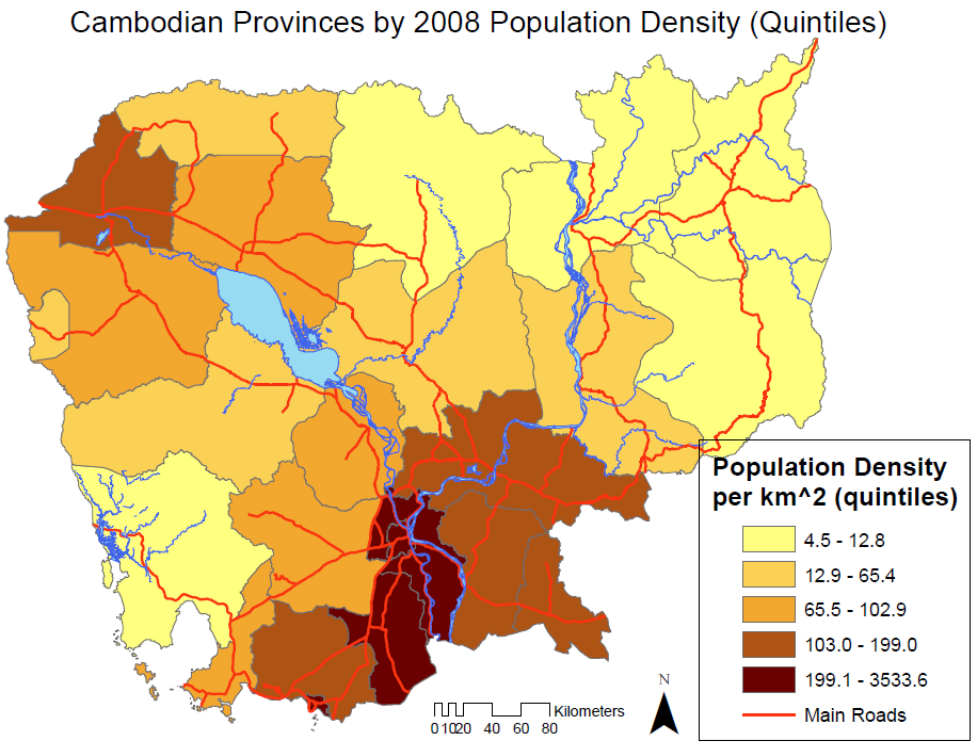

Table A1. Major Coding

Translated Major	Coded As
Agricultural Science	STEM
Agricultural Development	STEM
Agricultural Mechanical Engineering	STEM
Agricultural Technology and Management	STEM
Agriculture	STEM
Agronomy	STEM
Animal Science	STEM
Animal Science & Veterinarian	STEM
Architecture	STEM
Architecture & Urbanism	STEM
Architecture Decoration	STEM
Biology	STEM
Chemistry	STEM
Civil & Electrical Engineering	STEM
Civil Engineering	STEM
Computer	STEM
Computer Networking	STEM
Computer Science	STEM
Computer Studies	STEM
Creative Multimedia	STEM
Database Management	STEM
Dentistry	STEM
Electric	STEM
Electronics	STEM
Electrical Engineering	STEM
Engineering & Electricity	STEM
Environmental Science	STEM
Fisheries	STEM
Fisheries Science	STEM
Food & Processing (includes technology, biotech)	STEM
Forestry	STEM
Geography	STEM
Geology	STEM
Graphic Design	STEM
Horticulture	STEM
Information & Communication	STEM
Information Technology	STEM
IT	STEM
IT Business	STEM
IT for Armed Forces	STEM
IT Management	STEM
IT Systems for Business	STEM
IT Systems Management	STEM
IT- Business	STEM
Laboratory	STEM
Macrology	STEM
Mathematics	STEM
Mathematics & Science	STEM
Medicine	STEM
Midwife	STEM
Nuclear Engineering	STEM
Nursing	STEM
Nursing & Midwifery	STEM
Pediatry *(sp)*	STEM
Pharmacy	STEM
Physics	STEM
Power - Electricity	STEM
Science & Technology	STEM
Science Engineering	STEM
Technical for Medical Care	STEM
Technology Management	STEM
Technology of Computer Networking	STEM
Veterinary	STEM
Web Design & Technology	STEM

Note. Major names were carefully translated from Khmer with the assistance of two native speaking Cambodian scholars: one is a former Center for Khmer Studies fellow and another is a Cambodian university faculty member, specializing in English language. The first and second author also verified and cross-checked with English language versions of websites for these universities, when these versions were available.

Table A2. Characteristics Within Cambodian Provinces

	1	2	3	4	5	6	7	9	10
	Banteay Meanchey	Battambang	Kampong Cham	Kampong Chhnang	Kampong Speu	Kampong Thom	Kampot	Koh Kong	Kratié
Socioeconomic Development Indicators									
Average household size	4.60	4.80	4.50	4.60	4.80	4.70	4.50	4.80	4.80
Urban density (*scale*)	-0.98	-1.15	-1.30	-1.30	-1.32	-1.39	-1.30	-0.95	-1.29
Urbanicity	26.76	17.64	7.04	9.13	7.60	5.05	8.24	30.69	11.27
Population density	110.30	86.40	177.30	89.20	102.90	50.70	124.10	10.60	26.60
High resources scale (*scale*)	-1.54	-1.58	-1.95	-2.12	-2.12	-2.15	2.07	-1.14	-2.05
Airport in province	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light source	30.46	25.07	17.86	12.05	11.09	11.96	12.87	48.32	14.35
Cooking fuel	4.98	3.28	2.45	1.28	1.82	1.18	1.91	13.01	1.42
Toilet facilities	31.57	35.69	19.08	15.05	14.79	13.25	16.34	31.56	17.48
Gender Equity Indicators									
% Women employed	59.92	57.23	61.72	63.93	64.23	61.41	63.81	48.12	57.47
% Women enrolled in PSE	43.00	40.00	47.00	46.00	51.00	47.00	45.00	19.00	50.00
Female educational access (*scale*)	-1.34	-1.01	-1.60	-1.32	-1.56	-1.88	-1.51	-1.69	-1.69
Average age of marriage for women	22.90	23.40	22.40	23.10	22.60	22.50	22.40	22.20	22.10
% Literate females above age 15	69.03	72.31	67.32	68.60	66.96	60.65	69.29	66.75	67.54
% Females with PSE above 25	0.09	0.11	0.05	0.05	0.04	0.06	0.06	0.07	0.05
Student Demographics									
% scholarship students enrolled in PSE	11.00	12.00	29.00	91.00	3.00	27.00	9.00	0.00	6.00

Source. The 2008 Cambodian Census, province-level variables. Numbers correspond to official Cambodian province identification numbers. Six provinces with no higher education institutions in 2011-2012 are included (excludes Kandal, Mondulkiri, Preah Vihear, Oddar Meanchey, Kep, and Pailin). Further information about the coding of our institutions, provinces, and/or variables is in the Methodology section of this manuscript.

Table A2. Characteristics Within Cambodian Provinces

	12	14	15	16	17	18	19	20	21
	Phnom Penh	Prey Veng	Pursat	Ratanakiri	Siem Reap	Preah Sihanouk	Stung Treng	Svay Rieng	Takéo
Socioeconomic Development Indicators									
Average household size	5.00	4.20	4.70	5.40	4.90	4.80	5.20	4.20	4.60
Urban density (*scale*)	1.63	-1.36	-1.37	-1.27	-1.12	-0.75	-1.23	-1.37	-1.37
Urbanicity	93.63	3.49	6.46	12.84	19.44	40.40	15.24	3.53	1.71
Population density	3533.60	199.00	34.30	12.80	85.00	85.60	9.30	168.30	242.10
High resources scale (*scale*)	2.18	-2.24	-2.08	-1.98	-0.76	0.14	-1.77	-2.09	-2.03
Airport in province	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00
Light source	94.76	7.61	16.37	21.69	23.42	58.27	22.13	12.12	11.78
Cooking fuel	58.05	1.39	1.42	3.35	7.68	12.29	1.69	3.16	2.22
Toilet facilities	89.38	10.65	13.65	12.57	23.94	45.46	27.75	14.39	19.93
Gender Equity Indicators									
% Women employed	52.28	66.52	62.84	64.23	61.17	48.25	60.21	68.12	64.42
% Women enrolled in PSE	37.00	41.00	41.00	35.00	32.00	43.00	38.00	35.00	46.00
Female educational access (*scale*)	1.94	-1.54	-1.18	-3.59	-1.53	-0.78	-2.30	-1.63	-1.45
Average age of marriage for women	26.30	22.00	23.30	20.70	23.20	23.60	22.30	22.10	22.70
% Literate females above age 15	90.57	71.36	70.04	36.55	61.79	73.41	53.12	68.96	68.56
% Females with PSE above 25	2.14	0.04	0.06	0.05	0.18	0.32	0.05	0.05	0.05
Student Demographics									
% scholarship students enrolled in PSE	12.00	35.00	16.00	2.00	5.00	24.00	7.00	28.00	14.00

Source. The 2008 Cambodian Census, province-level variables. Numbers correspond to official Cambodian province identification numbers. Six provinces with no higher education institutions in 2011-2012 are included (excludes Kandal, Mondulkiri, Preah Vihear, Oddar Meanchey, Kep, and Pailin). Further information about the coding of our institutions, provinces, and/or variables is in the Methodology section of this manuscript.