# Immigration and the Diffusion of Technology: The Huguenot Diaspora in Prussia

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## Abstract

This paper analyzes long-term effects of skilled-worker immigration on productivity for the Huguenots migration to Prussia. We combine Huguenot immigration lists from 1700 with Prussian firm-level data on the value of inputs and outputs in 1802 in a unique data base. In 1685, religious persecution drove highly skilled Huguenots out of France into backward Brandenburg-Prussia where they were channeled into towns to compensate population losses due to plagues during the Thirty Years' War. Exploiting this settlement pattern in an instrumental-variable approach, we still find causal effects of Huguenot settlement on the productivity of textile manufactories hundred years after their immigration.

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# 1 Introduction

The impact of immigration on the host economy is a controversial issue both in research and in the political debate. Gains from skilled immigration are generally argued to be large if the productive abilities of immigrants are different from those of natives (Borjas, 1995). The imported human capital can either have direct effects on the productivity of a country, or external effects on the productivity of native human capital through the interpersonal transfer of technology and skill (Bodvarsson and Van den Berg, 2009). While the literature provides evidence for immediate productivity gains from immigration (Peri, 2011), empirical evidence for the indirect effects on the productivity of natives, which might occur only in the long run, is largely missing. With the help of historical data, this paper aims to analyze such long-term effects of skilled-worker immigration on productivity in the host country.

We construct a unique new dataset combining historical sources that document the immigration of French Protestants into Prussia and the productivity of Prussian manufactories roughly 100 years after their immigration. The religious flight of the so-called Huguenots in the seventeenth century is one of the earliest examples of skilled mass migration leading to technological transfers (Scoville, 1952a,b). Using Prussian immigration lists from 1700 that document the settlement of Huguenots precisely, we are able to observe the immigration of a population that was, on average, more skilled than the native population. The data are unique in the sense that Prussia was the only host country to keep exact records of the French refugees. In combination with firm-level data on the value of inputs and outputs for all 693 textile manufactories in 1802, we find positive long-term effects of immigration on productivity. To our knowledge, both data sources have not been used in previous econometric analysis.

We argue that, by the order of centralized ruling by the King and his agents, Huguenots were channeled into Prussian towns in order to compensate for severe population losses during the Thirty Years' War (1618-1648). This allows us to interpret the settlement pattern as a natural experiment and to use the population losses in an instrumental-variable approach. Connecting data on the population decrease in Prussian towns during

the war with the share of Huguenots in Prussian towns, we are able to identify exogenous variation in the settlement pattern and eliminate a possible selectivity of choosing the location of settlement for immigrants. Using this IV approach, we find manufactories established in towns that were depopulated due to disease and famine during the war, and subsequently repopulated by the immigration of Huguenots, achieve a higher productivity in manufacturing textiles than others. Population losses during the war were arguably exogenous to economic conditions of a town. However, to overcome possible concerns of non-random placement we provide several falsification and validation tests corroborate the validity of our IV approach.

The economic impact of the Huguenots, who fled their country after the Edict of Nantes was revoked in 1685, has been a recurring theme in the literature. As early as in the middle of the nineteenth century, List (1856, p. 153) found that "Germany owes her first progress in manufactures to the revocation of the Edict of Nantes, and to the numerous refugees driven by that insane measure into almost every part of Germany...". We interpret this event as a exogenous shock, after which immigrants fled from religious persecution and settled in the predominantly Protestant neighbor countries of France.

The consequences of this exogenous shock are not well studied. Using anecdotal evidence Scoville (1952a) denies immediate returns from Huguenot immigration. In the short run, their arrival neither accelerated economic growth in England, nor closed the technological gap that separated Germany from France, Holland, or England. Nevertheless, Scoville (1960, p. 363) argues that the cost of accommodating the Huguenots was easily offset by the long-term gains. While contemporary and present-day literature provides cost-benefit analysis of Huguenot immigration, effects from knowledge spill-overs between refugees and natives which might only be observed in the long run are neglected. It is well known that the Huguenots were highly trained and skilled, and that on arrival at their destinations they started to use these superior skills to earn a living (Scoville, 1953). Most recently Fourie and von Fintel (2011) found that immigrant Huguenots in Dutch South Africa preserved their comparative advantage in wine production over the eighteenth century. In other cases, interaction with native workers might have led to a transfer of technical knowledge and to technological diffusion. Accordingly, German

scholars agree on the fact that the transfer of Huguenot knowledge had a certain positive effect on the Prussian economy (Jersch-Wenzel, 1978; Mittenzwei, 1987; Wilke, 1988b), econometric evidence is however missing.

The analysis of historical data has certain advantages since we are not only able to analyze long-term effects of immigration, but also to eliminate alternative channels of knowledge transfer. Technology features a tacit element, which requires direct communication between the user and the instructor of a new technology (Mokyr, 2002). As the growing number of modern forms of communication facilitate direct communication, measuring the unbiased effects from immigration is increasingly challenging. We avoid such problems by analyzing migration at a time when direct communication was virtually the only way of transferring technological knowledge. We exploit the fact that any means of indirect communication are negligible in this period and that immigrants in 1700 cannot have had any direct influence on productivity in 1802. Therefore, any productivity gain from immigration during this time is most likely to have been caused by interpersonal as well as intergenerational transfers of technology and skill.

The remainder of the paper is structured as follows. Section 2 gives insight into the related migration literature. Section 3 provides the historical background of Huguenot immigration into Brandenburg-Prussia. Section 4 introduces the dataset and its sources. In section 5 we formulate the empirical model and introduce the instrumental-variable approach. Section 6 presents OLS and IV results and tests their robustness. Section 7 concludes.

## 2 Economic Effects of Migration

The economic effects of modern migration are well-documented in the literature, especially in labor economics. This field distinguishes three major streams of research: the economic performance of immigrants, their effect on employment opportunities and wages of the natives, and the assessment of immigration policies for host countries (surveys by Borjas (1994, 1999); Friedberg and Hunt (1995)). The effect of immigration on natives' wages and labor market responses are certainly the most discussed, whereas the macroe-

conomic effects of immigration lack attention in the literature (Drinkwater et al., 2007). Studies of economic benefits from migration for the host country include Ben-Gad (2004), Chiswick et al. (1992) and Paserman (2008). The impact of immigration on innovation has been studied by Chellaraj et al. (2008), Hunt and Gauthier-Loiselle (2010) and Niebuhr (2010). An overview of historical migration and its impact is provided by Hatton (2010).

Theoretically, Borjas (1994, p. 1667) finds that immigrants with high levels of productivity who adapt rapidly to the labor market in the host country can make a significant contribution to economic growth. Borjas' (1995) influential "immigration surplus" finds immigration beneficial in a case where the immigrant skills are very different from those of the natives and their characteristics have a certain complementary to the native factors of production. He also finds that the knowledge transfer between natives and immigrants generates external effects leading to increasing returns to scale. In a simple model including capital he finds that the benefits from migration are large if the immigrants are skilled, thus having higher complementary with capital. This is even more relevant when the native population is rather unskilled. Borjas' findings are supported by Dolado et al. (1994) who find that immigration with low human capital is equal to an increase of the population - it slows down per capita growth. Similarly, if immigrants carry high levels of human capital which is complementary to native capital, per capita growth accelerates.

The unbiased analysis of knowledge transfers from immigrants to natives is almost impossible since diffusion processes are often affected by indirect channels of communication, like written or electronic media. Nevertheless, even if techniques are codified and explicit, interpretation by the user is needed. Successful interpretation thus requires a transfer of tacit knowledge between the instructor and the user (Mokyr, 2002). This means that even in today's environment, measuring the effect of transferring tacit knowledge through immigration is of particular interest to the understanding of technological diffusion.

A time when face-to-face contact was the only way to transfer knowledge provides the perfect setting to analyze the unbiased effects from technological diffusion through migration. Before the onset of the Industrial Revolution, innovation and diffusion rarely occurred as a result of the publication of written material or blueprints (Rosenberg,

1970), but rather through the migration of skilled craftsmen, financiers and entrepreneurs (Schilling, 1983, p. 8). At that time, the strongest obstacles to technological diffusion were mobility costs (Epstein, 2004). Furthermore, Cipolla (1972) notes that the effects of the printed word on historical diffusion of innovations are often overestimated, and direct communication was much more important when it came to application.

During the sixteenth and seventeenth centuries, mercantile policies started to gain influence over manufacturing and were aimed at stimulating innovation. Mokyr (1990, p. 78) provides some vivid examples of technological diffusion encouraged by European rulers. They attracted skilled foreign labor in order to apply foreign skills in the new host country and eventually transfer it to the natives. The literature widely agrees that this was a common way to diffuse knowledge during the Early Modern Ages and that host countries benefited substantially (Ciriacono, 2005; Findlay, 1978). Furthermore, it is agreed that Calvinists contributed substantially to the diffusion of technological knowledge during that time. The most famous example of Calvinist-migration was the exodus of Huguenots from France to the German Brandenburg-Prussia. Religious persecution increased the benefits from migration and thus helped to overcome obstacles to technological diffusion. In line with the aforementioned considerations of Borjas, Scoville (1951) argues that diffusion of skills and technologies was facilitated by the fact that Germany was a backward country in 1685.

One important caveat prevalent in the migration literature is that immigrant inflow is rarely accidental and immigration policies are most likely to be highly selective in the attraction of certain characteristics. Furthermore, it is often argued that immigrants are more mobile than natives and will move to regions with higher wages and probability for economic success. Usually this leads to two kinds of selection: selection based on the characteristics of the immigrants and selection based on their places of settlement. In our case we prefer selection on the characteristics of the immigrants since we presume that they were highly skilled on average. In order to analyze benefits from the knowledge transfer without observing individual skills of immigrants, we assume that the immigrants are pre-selected and, on average, more skilled than the natives. The second kind, selection on the place of settlement, can be ruled out in a natural experiment where e.g. timing

and relocation of immigrants are motivated by a policy free from economic considerations. The problems arising from the possible selection in the location of immigrants will be dealt with in Section 5.2.

# 3 History of Huguenot Migration to Prussia

This section summarizes the historical background of Huguenot immigration and provides narrative information of the consequences.

## 3.1 Immigration after the Edict of Potsdam

The persecution of Reformed Protestants in France started around 1530 and peaked at the St. Bartholomew's Day massacre of 1572 which was followed by a first wave of religious flight. From 1598 the Edict of Nantes granted religious freedom to the Huguenots until its revocation on October 18, 1685 by Louis XIV, the Sun King. Protestantism became illegal again and Huguenots were outlawed in the predominantly Catholic France. Protestant churches and schools were shut down and Huguenots once again became a target of persecution. While there was a constant outflow due to increasing harassment prior to the revocation, the movement grew into an exodus soon after. This was not anticipated by the King of France, who had assumed that only those people would leave who were in trouble with creditors or were without property and special skills, and therefore did not have strong connections to their homes (Scoville, 1960). Hence, he tried to force the Huguenots to convert to Catholicism. In spite of severe penalties such as life-long imprisonment, deportation into slavery or death, approximately 200,000 fled. Most of them settled in neighboring Protestant countries such as England, Germany, Ireland, the Netherlands and Switzerland.

The most famous example of those who offered refuge was Frederick William, the Great Elector of Brandenburg. Unlike his mostly Lutheran subjects, he was of Reformed faith and felt sympathy for his fellow Christians from France. Three weeks after Louis XIV revoked the Edict of Nantes, Frederick William issued the Edict of Potsdam offering his estates as a refuge to the Huguenots.[1]

[1] For a translated excerpt from the Edict see Appendix A

Of the estimated 43.000 Huguenots who left France[2] for the German territories, 16.000 to 20.000[3] alone came to Brandenburg-Prussia, a country of approximately 1.5 million inhabitants at that time. Since there already were some French nobles living in Frederick William's court, Berlin became the final destination of many Huguenots, following the Edict of Potsdam. By the beginning of the eighteenth century, more than 5,000 Huguenots had settled in Berlin and its outskirts, making up to 20 percent of the town's total population. The rest settled in roughly 40 other towns and some few rural parishes. In total, about 90 percent of the Huguenots settled in towns.

Frederick William was anxious that the French would leave if they felt alienated by the natives. So he allowed them to build communities of refugees, so-called colonies, in each town of their settlement. These were parishes with their own church and service and, depending on the size, their own jurisdiction, police and schooling.

The literature agrees that the rich and powerful Huguenots mostly fled to England and the Netherlands. This picture is maintained by various descriptions of impoverished and half naked Huguenots arriving in Brandenburg, having lost everything during the flight. Nevertheless, Wilke (1988c) emphasizes that it was not only the poor nor the second-class nobility who came to Prussia. According to him, the Huguenots came to Prussia as a complete draft of society. He estimates that the immigrants were composed of 5% nobility, 7% mid-level functionary, 8% trade and manufacturing bourgeoisie, 20% workers and apprentices, 15% farmers and 45% small artisans and craftsmen in 1705.

These figures already draw a clear-cut picture of the occupational composition which resembled a town population much more than a rural society. There were two reasons for this: First of all, Huguenots were generally very well-educated and had adopted more skilled occupations in France.[4] Second, in February 1686 Frederick William demanded

[2] Their origin was manifold; centers of emigration were the Languedoc (south), Dauphiné (south-east), the Champagne (north-east) and the Gascogne (south-west).

[3] Numbers vary with the inclusion of members of the military who were integrated into the Prussian army and thus not counted in colony lists.

[4] Scoville (1960) explains the economic advantage of the Calvinists over Catholics in France with their dominant role in public finance, their role as a "penalized minority", Protestant individualism and a Protestant ethic á la Max Weber. Incidentally, Scoville mentions Calvinist advocation of Bible reading. This might have translated into higher accumulation of human capital and skill (see Becker and Woessmann (2009) for similar arguments regarding Protestants in Prussia and Botticini and Eckstein (2005, 2007) for Jewish literacy and occupational selection).

that his delegates should refuse unskilled Huguenot workers to enter Brandenburg-Prussia (Mittenzwei, 1987).

### 3.2 The Economic Impact of French Immigrants

Frederick William, the Great Elector of Brandenburg, came into his reign in 1640 during the Thirty Years' War, which left the country depopulated and deserted after the Black Death had finally faded. The Margraviate of Brandenburg, Pomerania and Magdeburg, which made up most of his territory then, were hit hard by the war and suffered from the aftermath more than most other German states and kingdoms. Therefore, Frederick William and his successors became well-known for their repopulation policy (*Peuplierung*) and the intake of Huguenots was a major step to fulfil this aim.[5]

An increase in the population was perceived as a raise in the number of tax payers as well as a potential way to recruit more soldiers. Thus, the literature identifies economic motives for the intake of Huguenots (Jersch-Wenzel, 1978; Mittenzwei, 1987; Wilke, 1988a), while religious motives and sympathy towards fellow believers are not neglected. Skilled immigrants in particular were the most attractive targets and were expected to use their knowledge to set up and supervise manufactories. This was very much in line with the German economic thought of the seventeenth century (*Kameralismus*, a special kind of mercantilism) which was based on a positive balance of trade. The Huguenots were expected to produce 'domestic' goods that otherwise would have to be imported. Thus taking in the Huguenots, who were known to be good craftsmen, was an act of tolerance at first, but became an act of economic policy in hindsight.

Already in the Edict of Potsdam, Frederick William granted support and several privileges to all French refugees. This included exemptions from tariffs when entering the country, free use of abandoned houses and deserted land, exemption from all taxes and impositions except the consumption tax for 15 years, financial and material support for setting up businesses and manufactories, free land for those in agriculture and finally, freedom from guild coercion for 10 and later 15 years. All financial support was provided

[5] Frederick the Great pointed out at the beginning of his reign in 1740 that even after three regimes and nearly a century passed, the impact of the Thirty Years' War on the Margraviate, Pomerania and Magdeburg had not yet been made up for completely. Although massive efforts had been undertaken by each ruler to repopulate the land, it was not until the middle of the eighteenth century that the population reached pre-war levels (Franz, 1979, p. 100).

as a loan to be paid back once the businesses became profitable. This became necessary as many Huguenots had lost all of their possessions during the flight.[6] Soon the Huguenots went into business and most of them resumed occupations they already had had in France - concentrating on textiles and apparel. Approximately 25.7 percent of the Huguenot craftsmen were occupied with the production of cloth and 32 percent with other textiles.[7] As expected, the immigrants used their technological and managerial knowledge to set up manufactories, while the attempts made by their domestic counterparts were not able to surpass the lower stages of production (Jersch-Wenzel, 1978, p. 80).

Analyzing the economic impact of the Huguenots can only be attempted using historical sources. Unfortunately, most of the contemporary documentation seems to be somewhat clouded and biased in favor of self-adulation of the Prussian rulers. Consequently, the modern literature suffers from the lack of unbiased sources (Gwynn, 2001, p. 74).

This can be seen in some examples outlining the short-term benefits of hosting the Huguenots: When asked if his intentions to bring back Magdeburg to its former prosperity had been fulfilled, the King answered that the town had been idle for 40 years after the war, but when the refugees came all buildings had been filled within 18 years. Manufactories were established that had not been there before, foreign money had come to the town and hundreds of citizens were employed and contributed to consumption (Jersch-Wenzel, 1986, p. 163).

These statements are supported by a comparison of costs and benefits undertaken by the city council for the colony in Magdeburg in 1709, which found that Huguenot economic activities offset investments into them by far. In line with mercantile thinking, more people would lead to more wealth and costs caused by their privileges and subsidies should be offset by the additional consumption taxes. Based on the calculations of the city council, Jersch-Wenzel (1978) estimates an annual per-Huguenot return of 10 Thalers,

[6] Nevertheless Muret (1885) finds that some Huguenots purchased real estate, houses and manufactories with their own means and without subsidy.

[7] The data reflect the structure of Huguenot craftsmen in Berlin which, throughout the literature, is often used as a proxy representing all colonies in Brandenburg-Prussia. See Jersch-Wenzel (1978, pp. 72-74) for corresponding numbers in other professions.

throughout all colonies. This was approximately equal to the annual tax revenue obtained from every native. However, these calculations seem to be somewhat parsimonious and do not account for any external effects such as benefits resulting from technological diffusion.

The contemporary impressions of positive short-term benefits are nevertheless refuted rather than confirmed the in the modern literature. Refusals are mainly describe the ongoing attempts of Prussian rulers to hand out privileges and support to Huguenots to set up manufactories which seldom operated profitably and often went out of business soon after subsidies ran out (Jersch-Wenzel, 1978; Kindleberger, 1995; Scoville, 1960). The reasons for these failures were most often the lack of demand and markets for luxury goods, which were exactly the kind of products that were strongly supported by Prussian rulers. It was only the stocking production that succeeded in raising the necessary demand. Mittenzwei (1987, p. 124) suggests that Brandenburg-Prussia had not been ready for large-scale manufacturing at the beginning of the eighteenth century.

The long-term effects from immigration are similarly controversial. Mittenzwei (1987, p. 138) identifies four phases of Huguenot economic activity: A first phase of establishment from 1685 to the turn of the century, a boom phase in small-scale manufacturing up until 1735/36, a phase of decline up until 1767, and a phase of economic growth beyond the beginning of the nineteenth century. Mittenzwei's observation of growth around the turn of the nineteenth century is based on a massive increase in the number of looms for silk and cotton employed by members of the French colony in Berlin. She also observes a persistent downturn in the use of looms in the wool industry which was formerly dominated by Huguenots.

On the other hand, Jersch-Wenzel (1986) finds that the impact of the Huguenots on the Prussian economy and industry in particular lasted for nearly the whole eighteenth century but declined gradually towards the end. In 1797, a special commission filed a report stating that in the exact same way as the number of manufacturers had decreased in the colonies, the manufactories themselves were run-down (Jersch-Wenzel, 1986, p. 169). This impression might be due to increased assimilation. The homogeneity of the colony population eroded over time. Huguenots married into non-Huguenot families and left the

community to live as normal Prussians and vice versa. Obviously, the manufactories had moved out of the colonies along with their entrepreneurs.

Though Jersch-Wenzel assumes that the commission had not overrated the declining impact of the Huguenot community, she suggests that the transfer of knowledge had a long-lasting impact. She concludes that knowledge and skill immigrated from France to Prussia and made a successful contribution to the Prussian economy. Wilke (1988a) confirms this by stating that the Huguenots brought the knowledge of production in centralized and decentralized manufactories to Prussia, a country that had not yet entered the stage of capitalist manufactories. Though they were not successful in establishing manufactories that endured over the long run (for aforementioned reasons), the Huguenots transferred their technological knowledge to their native apprentices and workers.

This very idea is also the target of our empirical research. We presume that even if any direct Huguenot influence on the economy vanished over time, their transferred knowledge was still active and had a positive impact on productivity in the manufacturing of textiles.

### 3.3 Knowledge Lead and Transfer

The diffusion of technical knowledge, once concentrated in France, is confirmed across all new host countries by Scoville (1952a). As for England, he notes that the Huguenots raised the quality of production and diffused skills that once were secrets of French manufacturers. In Holland, the silk and taffeta industry suddenly gained international reputation through Huguenot immigration. In Ireland, Huguenots gained massive influence on the manufacturing of linen and introduced new methods for spinning and weaving flax.

The economic situation in Ireland was most similar to Prussia at the time. Both suffered from the aftermath of a war, and just as for Ireland, it is generally agreed that Brandenburg-Prussia was a backward country at the end of the seventeenth century. Neither the putting-out system nor the cottage industry nor centralized manufacturing had advanced in Brandenburg-Prussia. In the late 1670s, Prussian functionaries built few manufactories in Berlin, otherwise there was no larger scale manufacturing. These

state-forced enterprises were not driven by markets and thus either failed or performed dreadfully.

All in all, the Huguenots introduced both more advanced skills and new technologies. Bekmann (1751) found that they brought 46 professions to Brandenburg which were previously unknown to this country, most of them in the textile industries.[8] One Huguenot carried with him the secret of dyeing fabrics in a special way, another brought the art of printing on cotton. Others introduced the hosiery knitting loom which replaced the manual production of stockings and socks. Furthermore, they introduced the knowledge of silk farming and silk spinning, a trade which was very important to Frederick William. He soon ordered the cultivation of mulberry trees in schoolyards to feed the silkworms and assigned special areas designated for plantation around Berlin.

While it seems to be agreed that the Huguenots were leaders in technical knowledge and skill in many trades, examples of actual transfers and diffusion of knowledge taking place are rare. The segregation of Huguenots into colonies might have imposed barriers to interactions with natives. Other obstacles to communication might have been the hostility displayed by Catholic and Lutheran natives, who would at times even refuse buy from the Reformed Huguenots.

Nevertheless, there are clear signs of frequent knowledge transfers between Huguenot artisans instructing native apprentices and workers. This form of interaction was strongly encouraged by Frederick William. When immigrants requested financial support to set up manufactories, many of the contracts included a fixed number of employees[9] as well as the condition that they had to instruct native apprentices.[10] In Halle on the Saale, it was publicly proclaimed that citizens should send their children to become apprentice to French manufacturers.

Even if these large-scale manufactories did not last for long, they resulted in the training of native apprentices and provision of new equipment. The equipment was

[8] Frederick the Great remarked that: "When Frederick William (the Great Elector) began his reign, this country was producing neither hats and stockings, nor serge or other woolen stuff; French diligence delivered all those goods to us. They fabricated cloth, screen cloth, serge, gentle cloth, drugs, griset, crepe, woven caps and stockings, beaver- and rabbit-hats, rabbit-hair hats and built dyeing works of all kind." Cited from Erbe (1937, p. 83).

[9] The entrepreneur Orelly was contracted to employ at least 8000 workers, André, Valentin and Claparède had to employ 110 looms.

[10] Mittenzwei (1987, p. 118) lists three examples of contracts including the order to employ native apprentices and to teach them the craft.

eventually sold or leased to either some native or otherwise mostly Huguenot craftsmen who set up smaller businesses which were far more successful.

As Scoville (1952a, p. 410) puts it, the rate of technological diffusion depended on the channels of communication between Huguenots and natives and on the size of the technological gap between France and the immigration country.[11] In the case of Prussia, the rate of diffusion was likely to be low. Direct communication between Huguenots and natives, other than the instruction of apprentices, was important to make the immigrants socially accepted and to raise demand for their products. Therefore, it was not until some years into the Huguenot refuge, when assimilation advanced and the native Prussians started to accept the French, that technological diffusion also progressed. Furthermore, the technological gap that separated Brandenburg-Prussia from France was large compared to other host countries like England and the Netherlands, and this state of underdevelopment prevented it from reaping immediate benefits from accommodating the Huguenots.

The technological change introduced by the Huguenots was likely to have been too abrupt to be applied in this country at once. This is in line with Becker et al. (2011) who find that the progress of the textile industry in Prussia was more incremental than disruptive. Nevertheless, the transfer of knowledge increased the rate of applied technological change and led to a higher growth equilibrium. As we will show subsequently, those towns with a higher share of first-generation Huguenot refugees became more productive than other towns in the long run.

### 3.4 The Settlement Pattern of Huguenots

The literature rarely touches on the question of why the Huguenots settled in certain towns. In general, rather than being able to select themselves into their settlement places, the Huguenots were channeled into those towns the Prussian rulers found most adequate. The Edict of Potsdam declared that the Huguenots were free to choose their place of settlement, but at the same time made recommendations for several towns[12]

[11] Many others have found that the size of the technological gap determines the speed of a catch-up process (Gerschenkron, 1962; Findlay, 1978; Vandenbussche et al., 2006).

[12] See Appendix A for the corresponding paragraph in the Edict of Potsdam.

with sufficient livelihood (*Nahrung*).[13] Many of the *bürgerliche Nahrungen* still remained vacant after the Thirty Years' War and the Huguenots were invited to fill these gaps.

Jersch-Wenzel (1978) assumes that the towns recommended in the Edict of Potsdam were chosen because they were the few bigger ones that could profit from the Huguenots. Klingebiel (1990) finds that the settlement pattern of the Huguenots reflected the structural requirements of the German regions after the Thirty Years' War. Schilling (1983, p. 9) identifies this as a case where an absolutist bureaucracy controlled the settlement of Huguenots and determined the scope and the direction of their economic activities.

To better understand how the immigration took place, we provide some examples from the contemporary literature. The Edict of Potsdam suggests that the flight to Brandenburg-Prussia was well organized by Frederick William. Already in the Edict, he advised the Huguenots from the north to head to Amsterdam where they would be welcomed by his delegates. From there they would be shipped through Hamburg into his realm. The Huguenots from the south were told to come to Frankfurt on the Main or Cologne where they would receive everything necessary and passage down the river Rhine to Cleves.[14] The refugees usually moved in convoys from their home towns and arrived as groups at the assembly points where all immigrants were registered and their means and circumstances were recorded.

Afterwards, the Huguenots were assigned to a colony or settling place. According to Muret (1885), the welcoming delegates were to place the French where they would fit best and to transfer money required for their settlement from church collections. For example the commander of Lippstadt, Henri de Briquemault, placed all refugees from the Champagne region in the cities of Hamm, Soest, Minden and Lippstadt (Erbe, 1937, p. 34). As destination to host a large group of Huguenots which had to flee Mannheim[15], the Great Elector suggested the cities of Prenzlau, Halle on the Saale, and Magdeburg. Two delegates visited these towns and decided that the entire colony from Mannheim would

[13] *Nahrung* was at this time defined as the occupation which one performed in order to subsist. When a village was granted market rights or town privileges, this was associated with the right to perform "*bürgerliche Nahrungen*" (crafts), as opposed to agriculture. However, the number of *Nahrungen* was limited to assure sufficient subsistence of the artisans and to guarantee the supply of the town population with the manufactured product for adequate prices. The supervising authority was usually the guild.

[14] For a more detailed description of migration routes see Klingebiel (2000).

[15] After their flight from France, a large group of Huguenots had settled in Mannheim (Palatine). When the French troops captured the town in 1689, the complete colony had to relocate again and decided to move to Brandenburg-Prussia.

move to Magdeburg (Gabriel, 1990), which had almost completely been destroyed in the war. As the Black Death had killed another 2650 inhabitants in 1683, the Huguenots were more than welcome. Another example is the rural French settlement in East Prussia. The Black Death was rampant there between 1708 and 1710 and depopulated a total of 8411 farms. Soon after Frederick I issued the call for new settlers, the Huguenots came and established themselves in the assigned areas of Insterburg and Gumbinnen.

The aforementioned facts lead to the conclusion that the place of settlement was not as arbitrary as announced in the Edict. The Huguenots were rather assigned to where they were needed most to repopulate and revitalize the deserted towns. These were exactly the towns depopulated by the Thirty Years' War and the Black Death. As repopulation was one of the crucial motives for attracting the Huguenots, they were clearly assigned to towns that had suffered the most losses. This settlement pattern will be useful for our identification strategy.

## 4 The Data

This section introduces two new data sources which we digitized for the purpose of this project.

In order to estimate the long-term effect of Huguenot immigration on productivity, we need data that measure productivity for a period that is often called the statistical dark age. We are able to calculate productivity at the firm level, using very early data on manufactories across Prussian towns in 1802.[16] The manufacturing data are extracted from the "Register of Factories in the Prussian State" conducted by the Royal Prussian Secret Filing Department (Krug, 1805).[17] To our knowledge, this is the earliest published overview of this kind in Prussia. The register includes all factories established within Prussian borders of 1802 except for those in Ansbach, Bayreuth, Neuchâtel, Silesia, and the new territories gained as compensation for losses in the war with France. [18]

[16] 1802 was not a year with disturbing shocks to the Prussian economy. Those towns left of the river Rhine which had been annexed by Napoleon earlier are not included in the survey by definition. Other areas were not yet affected by the war and the Industrial Revolution had not started in Prussia.

[17] The department became the Prussian Statistical Office in 1805.

[18] We excluded 53, out of a total of 746 textile manufactories from the dataset in cases where manufactories were established in rural areas or in areas which did not belong to Prussia after 1807 (These are the spotted areas in Figure 2). We also excluded Huguenot settlements in rural areas since the occupation structure of rural colonies was very different.

During pre-industrial times, the expressions factory and manufactory were used synonymously in Prussia. However, there was a distinction between (manu)factory and craftsmen, where craftsmen produced on order and sold to a local demand, while (manu)factories produced larger quantities without order to satisfy national and even international markets (Hoffmann, 1969, p. 19). The latter form of production was also the criterion for inclusion in the survey.

The data includes the place and type of the manufactory, as well as the value of its manufactured goods, the value of raw materials used as inputs, the number of workers and the number of looms. Summary statistics are provided in Table 1. All manufactories were classified into 17 categories by their main input. Those manufactories classified as producing goods from wool, cotton, linen and silk represent our measure of textile manufacturing while all other categories will be used for a falsification test.

According to Krug (1805), the number of reported workers might be exposed to measurement error, mostly due to fluctuations during the year. For reasons unknown, data on the value of raw materials are missing for 96 of the textile manufactories. To be able to use a complete dataset, we impute missing values as described in Appendix B. We also have no information available on whether a manufactory was owned by or employed any Huguenots. However, as we aim to study the diffusion of technological knowledge it is not necessary to know about the physical presence of Huguenots in the production process

Data on the quantity of Huguenot immigration is very much unique for Brandenburg-Prussia. To our knowledge, none of the other host countries kept record of their immigrants. In Prussia, every French immigrant living in a colony was registered annually in the *Rôle général des Français refugiez dans les Estats de la Majesté le Roy de Prusse*. These immigration lists document the name of each Huguenot, the respective number of family members and servants, as well as his occupation. Because of continuous fluctuations in the first years (Jersch-Wenzel, 1985), we concentrate on the number of Huguenots living in towns and the number of Huguenots occupied in textiles in 1700 in order to estimate the impact of the first generation - the knowledge bearers.[19]

[19] The data source is Muret (1885).

To calculate the immigrant share at the town level, we use data from population censuses for Prussian towns provided in Schmoller (1922). Unfortunately, data on town population do not exist for 1700 and the first extensive census dates from 1730. The share of Huguenots in Prussian towns is thus defined as the number of Huguenots in 1700 over the town population in 1730. This definition would lead to an upward bias in the estimates only if the population in towns with Huguenot colonies systematically grew at a slower speed than others and vice versa.

In Figure 1 we present a map of Brandenburg-Prussia where grey areas depict her territory of 1685, the year the Edict of Potsdam was issued. Each town that subsequently hosted a Huguenot colony is marked with a cross. Most of the colonies that were founded after 1685 are located within these borders, except for the city of Stettin (Szczecin), whose colony was founded soon after the annexation of Swedish Pomerania in 1720. In Figure 2, towns with at least one textile manufactory are marked with a circle and towns with a Huguenot colony are again marked with a cross. We find that only eight towns hosting a Huguenot settlement did not subsequently develop large-scale textile manufacturing.

# 5 The Empirical Model

In this section we design the empirical model which will test our central hypothesis that a higher share of Huguenot population is associated with higher productivity in the long run.

## 5.1 The Productivity Model

We estimate productivity in textile manufacturing using a production function with technological progress:

$$\ln(\frac{Q}{L})_{ij} = \beta_1 \ln(A_j) + \beta_2 \ln(\frac{K}{L})_{ij}. \quad (1)$$

Productivity, defined as the ratio of output $Q$ to labor $L$, is determined by the ratio of capital $K$ to labor $L$ as well as the level of technology $A$. $Q$ is measured as the value of goods produced in manufactory $i$ in town $j$. $L$ is measured as the number of workers

and $K$ is represented by two variables: the number of looms and the value of materials used. $Q$, $L$ and $K$ are calculated in natural logarithms.

The share of Huguenots in a town's population enters as a measure determining the technology parameter $A$. The technological progress, brought by the Huguenots, came as a shock to the Prussian towns and varies with the ratio of Huguenots to natives, since technological diffusion is likely to increase with growing interaction possibilities. We assume that the exogenous technological progress caused by the Huguenots is Hicks-neutral. Both capital and labor are augmented; capital through the introduction of new and better looms and labor through the transfer of knowledge for more skillful application of the looms. This leads to the following estimating equation:

$$\begin{aligned} \ln(\tfrac{Output}{Worker})_{ij} &= \beta_0 + \beta_1(\tfrac{Huguenots}{TownPopulation})_j + \beta_2 \ln(\tfrac{Materials}{Worker})_{ij} \\ &\quad + \beta_3 \ln(\tfrac{Looms}{Worker})_{ij} + X_j'\gamma + u_{ij}. \end{aligned} \tag{2}$$

$X$ is a vector of characteristics that might have an influence on output and productivity (town size, availability of raw materials, religious composition of the population).

### 5.2 Exogenous Variation from Population Losses during the Thirty Years' War

In Chapter 3.4, we concluded that Huguenots, who came as an exogenous shock to the towns of Brandenburg-Prussia, were not able to select themselves into certain towns. However, if Prussian officials deliberately assigned Huguenots to towns for reasons that are unobserved but associated with productivity in textile manufacturing, estimation results might still be biased.

Even though their place of settlement was not randomly assigned, the Huguenots were channeled into towns which had been war-strapped and depopulated by plagues. We exploit this fact in an instrumental-variable strategy, where population losses during the Thirty Years' War serve as an instrument for the share of Huguenot population. This approach uses only that part of variation in Huguenot immigration that is due to the exogenous depopulation of a town during the war.

The Thirty Years' War (1618-48) is a period of strong devastation and thus naturally one of the darkest spots in German demographic research. Even parish and tax registers, usually reliable sources for calculation of the population, are sparse. The only part of Prussia with sufficient information on population losses in towns is the Margraviate of Brandenburg. For other areas we have to draw on sources not exclusively taken for this purpose. We use population data for the closest pre-war date available and the closest post-war date available from the German handbook of towns (Keyser, 1939-1941), interpolate[20] them and calculate population losses at the town level. Where available, we also use data from Behre (1905) and Wohlfeil (1976) and calculate the average population loss over the three data sources (see Figure 3 for availability of the instrument).

The first stage of the instrumental-variable approach predicts the population share of Huguenots in a town $j$ with the population decrease of the town during the war period:

$$(\tfrac{Huguenots}{TownPopulation})_j \quad = \quad \pi_0 + \pi_1 PopLosses_j + X'_{ij}\delta + \nu_{ij}. \tag{3}$$

Exogeneity comes from the fact that the largest part of population losses did not emerge due to the act of war itself but through the occurrence of the Black Death in the 1620s and 1630s. Depopulation in this case can be interpreted as an event independent of a towns' economic activities and conditions, since epidemic mortality did not depend, for example, on social classes or size of the settlement (Voigtländer and Voth, 2009). The epidemics were spread by roaming troops, returning soldiers and fleeing peasants seeking refuge in towns (Pfister, 2007). The hygienic situation eventually translated into plague, dysentery and typhus and resulted in massive decimation. Moreover, high infant mortality reduced long-term population growth. Baptisms, as an indicator, remained very low even for the generation to follow. As we will try to demonstrate, our instrument is not affected by measures associated with textile production, and resulting estimates show the causal effect of Huguenot diffusion on textile manufacturing.

[20] See Appendix C for details. Interpolation increases the power of the instrument. However, using the original data does not affect the results substantially.

# 6 Results

This section provides the empirical analysis of the effects of Huguenot immigration on productivity. For this purpose, we exploit variation in Huguenot settlement and in the productivity of manufactories across Prussian towns between 1700 and 1802.

## 6.1 Basic Results

Table 2 shows basic results from OLS regressions for the 693 manufactories producing textiles across 302 Prussian towns. Throughout the regressions, we assume heteroskedasticity, since the errors might be correlated within towns. We therefore cluster standard errors at the town level.

A simple bivariate regression, shown in column 1, introduces the share of first generation Huguenots in the town's population in 1700. We find that the share of Huguenots is positively correlated with productivity in textile manufacturing in 1802.

When controlling for firm-level input factors in column 2, we find that the share of Huguenots remains significantly associated with productivity. The value of materials per worker adds a lot of power in predicting the productivity of a firm. The number of looms employed also has a positive but smaller effect. Manufactories that did not employ any looms appear to be even more productive. This is no surprise since these are only manufactories producing hats and gloves, and thus luxury goods with an high output value. Since we used imputational methods in cases where information on the value of input materials was missing, we include a dummy to identify these observations in each regression. This dummy is not significantly correlated with the dependent variable, which means that manufactories with missing input information did not systematically differ in their productivity.[21]

Our results indicate that an increase in the share of Huguenots by one percentage point translates into a 1.4 percentage point higher productivity in 1802, or alternatively, if Huguenot immigration increases by one standard deviation, productivity increases by 0.07 standard deviations. [22] We interpret this result as a very conservative estimate

[21] Casewise deletion of observations with missing data (see Appendix B for further information) leads to similar results. The Huguenot coefficient is 1.405 with a t-statistic of 20.25.

[22] The mean share of Huguenots is 5.8 percent in a sample restricted to hosting towns.

because knowledge spill-overs to other towns might also have increased productivity there. It is therefore rather intriguing that productivity differences can still be observed after such a long time. Compared to an average annual European (agricultural) TFP growth of 0.2 percentage points (Persson, 2010), the gap does not seem too small.

Our estimates prove to be robust against the inclusion of several control variables.[23] In column 3, we control for the size of the town, since productivity and wages are usually higher in larger cities and a large town population might have an effect on prices of outputs sold and inputs purchased. Furthermore, input prices, especially in textiles, might be associated with availability of raw materials like wool. Thus, we include the number of sheep per capita at the county level. We find both variables not having an effect significantly different from zero. The size of the Huguenot coefficient is hardly affected.

The inclusion of the share of Protestants, which also might have had an effect on the diffusion of Huguenot knowledge since Protestants were probably less hostile than Catholics,[24] does not enter the model significantly (column 4). Furthermore, the inclusion of a dummy controlling for towns that did not belong to Prussia before 1700 does not change the coefficient for Huguenot diffusion. The intuition behind this dummy is to control for Prussian annexations after the big waves of Huguenot immigration. Very few colonies were established in these newly acquired towns. Additionally, this dummy controls for a possible east/west bias, since most of the territory acquired after 1700 is located in the former Kingdom of Poland.

If the settlement of Huguenots in Prussia only reflected the occurrence of pre-immigration textile production, our estimates would be driven by a path dependency prevalent in textiles. It might be that textile production in cities that hosted Huguenots achieved higher productivity in 1802 simply because they had been a center of textile production before their immigration. We deal with this concern by controlling for the progress attained in textiles before the Huguenots arrived. An Edict of 1680 documents the economic conditions of Brandenburg-Prussia, and found that due to the prevalent impact of the war on

[23] Unless specified otherwise, the source for the control variables is Mützell (1823-1825).

[24] Mokyr (1990) makes the point that Protestants are generally tolerant and thus more open to innovation and technological change.

most towns, the economy had still not reached the same level it had before 1618. The only craft of nationwide relevance was cloth production which was located in 24 towns (Mittenzwei, 1987). Since quantitative information of the state of textile production is not available for this time, we construct a dummy identifying those 24 towns. Column 5 in Table 2 shows the estimates when including the dummy. The dummy is not significantly associated with textile productivity in 1802, showing that pre-immigration textile towns are not the same as post-immigration textile towns.

In Table 3, we test whether the results hold when altering the explanatory variable of interest. As mentioned earlier, we use town population data from 1730 as the denominator, which might result in underestimating the effect if those towns hosting Huguenots systematically grew at a higher speed between 1700 and 1730. Using immigration list data from 1720 (GStA PK, 1720), we can calculate a more accurate ratio. Changing to the 1720 immigration list, we find the coefficient rising from 1.44 to 1.84, which hints at a downward bias in the results for 1700.

In column 2 we find that the share of Huguenots in 1795 does not have a significant effect on productivity, as opposed to earlier dates.[25] This means that the distant ancestors of the immigrants did not have a direct effect on productivity. There are several reasons for this: First of all, from 1720 on, newly immigrated Huguenots seem to have focused more on agriculture. Most of those immigrants were directed to rural settlements, but even for Berlin a shift in occupation towards farming could be observed. During the eighteenth century, the number of Huguenots working as farmers increased to 20 percent. These were mostly unskilled workers who were pushed off to the countryside (Wilke, 1988c, p. 58). Furthermore, the homogeneity of the group was eroded when natives married into the wealthy Huguenot families. From 1772 on, Prussians could become members of the colonies even if they were not Reformed Christians. Furthermore, many Huguenots left the colonies and became assimilated. Since only those refugees living in colonies were recorded on the lists, growing assimilation led to measurement error in the data. This might be the reason for the increased standard errors.

[25] The denominator here is town population in 1802.

While the share of Huguenots in a town's population is a good measure of immigration in general, such a variable neglects the possibility that only Huguenots employed in textiles might have transferred the relevant knowledge for textile production. We therefore use the number of Huguenots in textiles as an alternative variable of interest. The number of Huguenots employed in textiles in 1700 is positively associated with productivity in textiles in 1802 and the results shown in column 3 are qualitatively similar to previous estimations. Furthermore, we find that a dummy, reflecting Huguenot influence on a town in general achieves similar results (column 4). The variable of interest thus proves to be robust against changes in definition.

When running our different immigration measures against each other (column 5), we find that the effect is mainly absorbed by the immigrant share in 1700. We thus concentrate on the first generation of immigrants, who were the bearers of new technology and knowledge by definition.

### 6.2 Instrumental-Variable Results

So far, we included a measure of pre-immigration textile production in our estimations to control for the possibility that Huguenots were selected into towns with a prospering textile industry. Nevertheless, other possible patterns of selection might remain, and settlement could have been driven by unobserved factors that are not exogenous to productivity in 1802. We proceed using population losses during the Thirty Years' War as an instrumental variable.

As mentioned before, population data for the war period is very scarce and information is unavailable for many towns in our dataset, which results in a reduction of our sample size. Column 1 in Table 4 reports results of an OLS estimation when using the smaller sample for which data on population losses are available. Results in the small sample are similar to the large sample in Table 2; the coefficient of interest is slightly higher but the difference is not statistically significant. The reduced-form relationship between population losses in the Thirty Years' War and productivity in textile manufacturing 1802 (column 2) is positive and significant.

The first stage of the instrumental-variable approach (column 3) shows that population losses can be used as an instrument for the share of the Huguenot population in 1700. A decrease in the population by 52 percentage points (the average losses across Prussian tonws) is associated with an increase of Huguenots in the town population by 5.3 percentage points. The second-stage estimate is significant and slightly higher than the OLS estimate.[26] We also report the Kleibergen-Paap test statistic for weak instruments in column 4. An F-statistic of 5.7 might raise concerns whether the instrument is sufficiently strong (Stock and Yogo, 2005).[27]

Nevertheless, we can use the number of Huguenots occupied in textiles in 1700 as an alternative measure to the population share of Huguenots. In column 6, we find this measure of technological diffusion instrumented by the population losses during the Thirty Years' War being significantly associated with productivity. For this specification, the Kleibergen-Paap test has a value of 15.4 in the presence of clustered standard errors at the town level. Similar results are obtained when using a dummy for towns hosting a Huguenot colony (not shown).

### 6.3 Testing for Instrument Validity and further Discussion

This section provides a discussion and interpretation of the results and addresses some questions that might arise.

A falsification test, using non-textile manufactories might eliminate concerns of unobserved heterogeneity at the town level. If Huguenots settled in towns that subsequently established successful manufactories because of unobserved economic effects at the town level, we should also observe these effects on industries that were not advanced by immigration. Using information from non-textile manufactories that are also included in the 1802 survey, we show that the positive effect of Huguenot immigration was restricted to textile manufacturing. First, in Table 5 we show that Huguenot immigration had a significant positive effect on all subcategories of textile manufacturing. Second, in Table 6 we show that this positive effect cannot be observed in the non-textile sectors. Column

[26] To test if the results are driven by the massive Huguenot immigration and large-scale manufactories in Berlin, we also estimate the model excluding this city. All results remain qualitatively unaffected (not shown).

[27] When we employ robust standard errors instead of clustering at the town level, the model passes the weak instrument test using the proposed critical value of 10 (not shown).

1 shows estimates for all 695 non-textile manufactories. We do not find that Huguenot immigration had a significant effect on these manufactories. Further disaggregation into subcategories in columns 2-6 shows that the Huguenot effect cannot be observed in any of these industries.[28] Identification is thus unlikely to be driven by any unobserved town effects that affected all industries.

Throughout the literature we find examples of Huguenots who advanced other trades besides textiles in their host countries. In Brandenburg-Prussia, they were also known to be watchmakers, goldsmiths, wigmakers, tobacco farmers and producers of glass, paper, and small metal goods (needles and pins). Nevertheless, since we do not find any significant effect on non-textile industries, we conclude that the Huguenot immigration might not have been crucial for large-scale non-textile production.

As mentioned above, the reduced-form relationship between population losses and productivity is positive and significant. A resulting concern might be a violation of the exclusion restriction if the instrument had a direct effect on the outcome. If, for example, towns that suffered high population losses because of plagues subsequently experienced increasing real wages, decreasing interest rates or changes in the institutional framework and were thus able to become more productive, our estimates might reflect this effect (Pamuk, 2007). A positive selection might arise if Huguenots subsequently settled in these high-wage, low-interest towns. When excluding towns with Huguenot colonies from the regression, we find a negative but insignificant correlation between population losses during the Thirty Years' War and productivity in textile manufacturing (not shown). This means, if we only compare towns without Huguenot immigrations, we find that towns with higher population losses subsequently achieved (insignificant) lower productivity. We thus find no violation of the exclusion restriction.

If the instrument was affected by economic pre-conditions of a town that also affected productivity in textile manufacturing later on, the estimates might be biased. We try to test for this possibility by showing correlations between the instrument and pre-war conditions of the towns in Table 7.

[28] Nine other subcategories with very few observations are not shown, since sufficient asymptotic properties are missing to reasonably interpret the results. A positive correlation can be found in the paper and soap industries. Scoville (1952b) mentions that Huguenots in Brandenburg-Prussia produced soaps to wash and improve the quality of wool, so the soap industry might have been strongly affected by the textile industry.

Large towns might have a higher potential for population losses due to disease, but also for subsequent recovery. We show that the correlation between population losses and the size of the population before the outbreak of the war is negative and statistically insignificant at the town level (column 1).

Better accessibility of a town not only leads to more exchange of goods, it also leads to more exchange of germs and thus a higher risk of plague import. Our estimates might thus be biased if towns that were connected to roads lost a higher share of population during the war but also achieved higher productivity due to their integration in trade after the war. Using a seventeenth century map of Hanseatic trade routes (Bruns and Weczerka, 1962), we construct a variable that counts the number of roads entering a town. The town-level correlation between the number of roads and the population losses during the Thirty Years' War is positive but statistically insignificant (column 2).

Finally, a town that has existed for a long time might create institutions like markets, guilds and courts that lead to more interaction and thus a higher risk of diseases. We crudely measure institutions by the year when a town was first documented as holding city rights (Source: Keyser (1939-1941)). The town-level correlation between the documented year and population losses during the Thirty Years' War is small and statistically insignificant (column 3).

This means that it was neither the relatively bigger towns with a higher potential for recovery, nor those better connected in trade or with better institutions that suffered the most population losses during the war.

The dispersion of Huguenots all over Protestant Europe is likely to have led to the development of a transnational network of refugees. Ties with other Huguenot families might have led to advantages in international trade if immigrants were able to export their goods more successfully than their native counterparts. This means that even if immigration led to a long-term increase in productivity, it may not have been the result of technological diffusion but of network externalities.

If this was the case, the early Huguenot manufactories should have been most successful, since networks are likely to be the strongest between first generation immigrants. Many examples of failing manufactories during the early decades seem to rule out this

possibility. It had been the lack of demand that drove almost all of these enterprises out of business. We support this argument by analyzing the year of establishment using a list of Prussian manufactories from 1769 (Hoffmann, 1969).[29] The average date of establishment of the 558 manufactories that provided this information is 1753 and only 8 were founded before 1700. If many of these manufactories were Huguenot owned, it was at least by the second generation.

In pre-industrial times, the transfer of tacit knowledge was often limited to cities or even city quarters and processes were kept as secret as possible, especially within guilds. Nevertheless, Huguenots probably traveled to other towns and diffused some of their knowledge there. Furthermore, natives that had acquired Huguenot knowledge and technology might have relocated. In any case, diffusion beyond town limits leads to an underestimation of the effect of Huguenot immigration.

## 7 Conclusion

The analysis undertaken in this paper empirically confirms the existence of positive long-term effects from skilled immigration on productivity. We show that textile manufactories in towns hosting a higher share of Huguenot-refugees in 1700 achieved higher levels of productivity in 1802. We interpret this result insofar that the immigration of highly skilled Huguenots led to technological diffusion and knowledge transfer between the Huguenots and the natives, which translated into a long-term increase in productivity of the textile sector. Most of the existing literature on this topic suffers from a possible bias in historical sources that drew a one-sided picture and concentrated on positive examples in order to please the King of Prussia - econometric evidence was missing completely.

We are able to connect town-level immigration data from 1700 to firm-level manufacturing data from 1802 to present a comparative analysis of the benefits from Huguenot migration over all Prussian colonies and towns. Our estimates suggest that there has indeed been a diffusion of technologies and knowledge resulting from the targeted immigration of skilled workers. Despite the possible technological diffusion to towns without Huguenot immigration, the impact of the knowledge transfer can still be observed in the

[29] Unlike the manufacturing data from 1802, the 1769 data do include the year of establishment.

original host towns more than a hundred years later. Moreover, the effect is restricted to the industry which was the main field of activity for the immigrants - textile manufacturing. These findings strongly support the assumption of intra-industry spill-overs from specialized immigrants.

Our results also contribute to the understanding of technological diffusion before the Industrial Revolution, when migration of journeymen and traveling apprentices was virtually the only way to diffuse new inventions and work processes. Unfortunately, these singular events are not documented and their consequences cannot be analyzed today. Therefore, the mass migration of Huguenots serves as a natural experiment that enables us to quantify the longevity of technological diffusion in pre-industrial times. While the attraction of journeymen and masters to prosperous towns results in highly endogenous knowledge transfers, we are able to identify variation in the immigration of skilled workers that is exogenous to the pre-migration success of a town.

Our empirical identification strategy employs the exogenous variation in Huguenot immigration that results from population losses due to Thirty Years' War and ensuing plagues, and allows us to interpret the results as a causal relationship. The relevance of our instrument is confirmed throughout the literature where the the immigration of Huguenots is often associated with the population losses during the war. Thus we are able to isolate a part of the variation in immigration that results from factors exogenous to the outcome - productivity in textile manufacturing.

The results confirm List's (1856) argument that Germany might owe some of her early growth to the immigration of skilled human capital, in a way that could not have been observed by contemporaries. This might be one of the rare examples in which we are able observe the transfer of knowledge through migration which was unaffected by any indirect means of communication. The effects of such transfers can be verified only in the long run and might often be neglected in short-term analysis.

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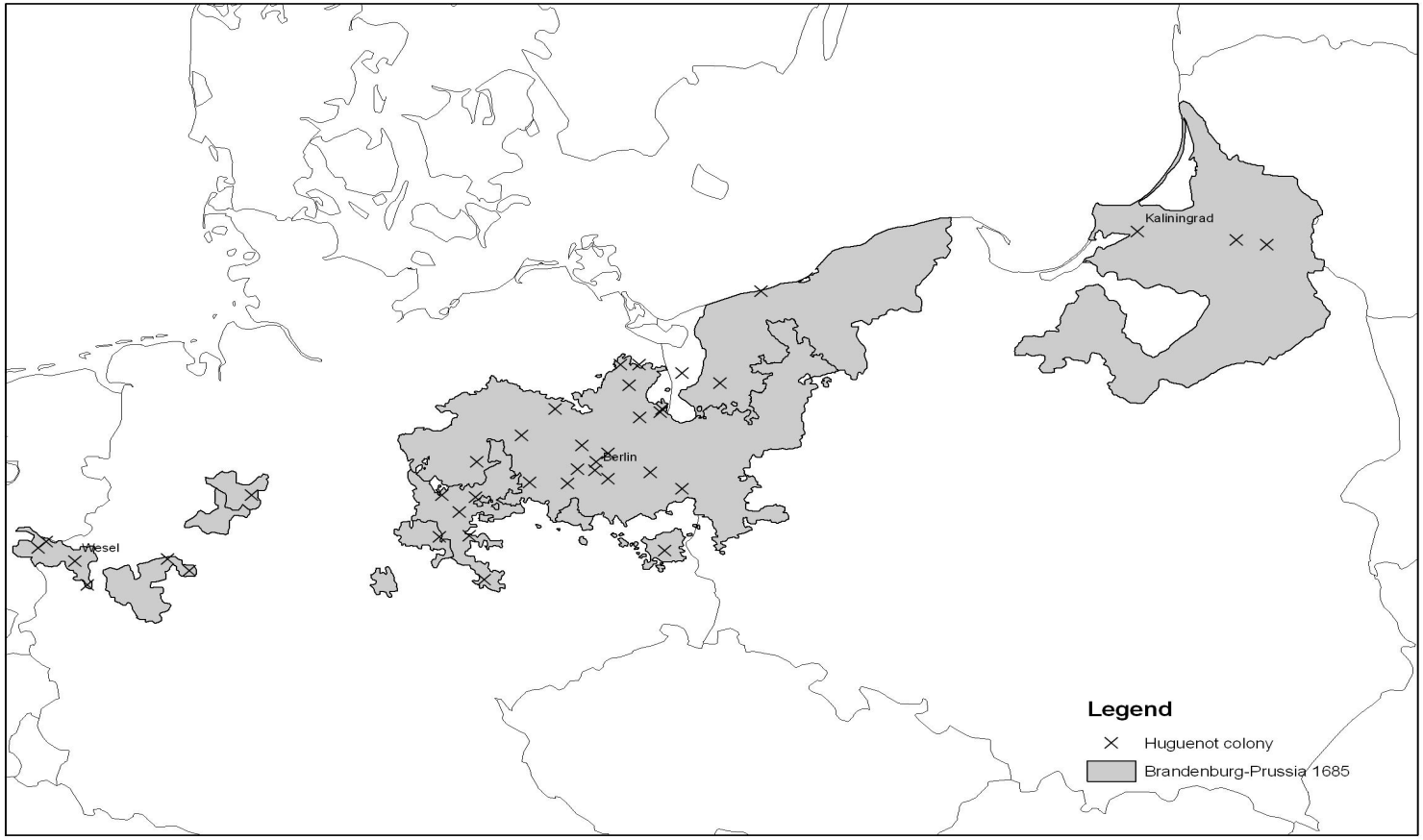
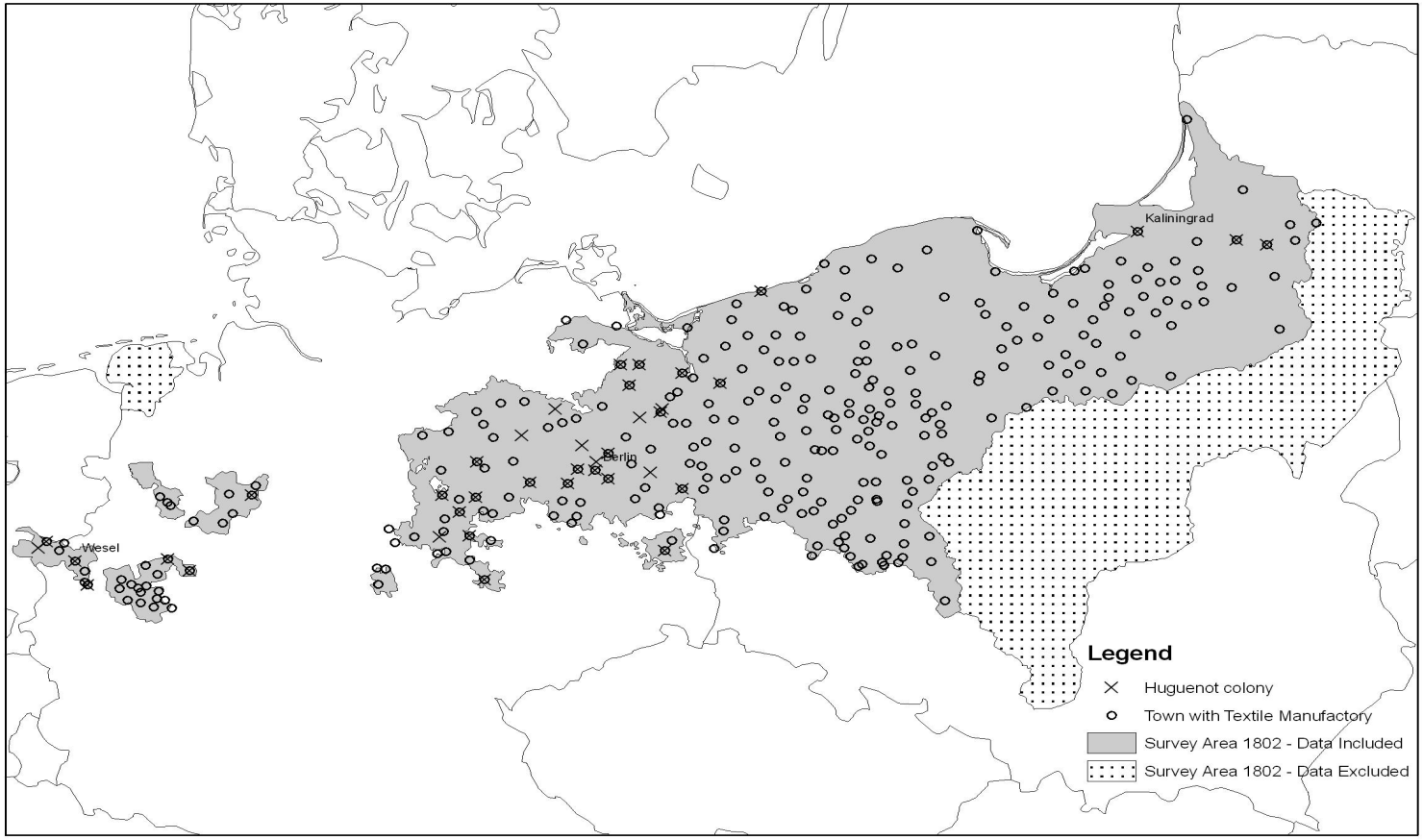
Figure 1: Towns with Huguenot Colonies in Prussia, 1685-1795



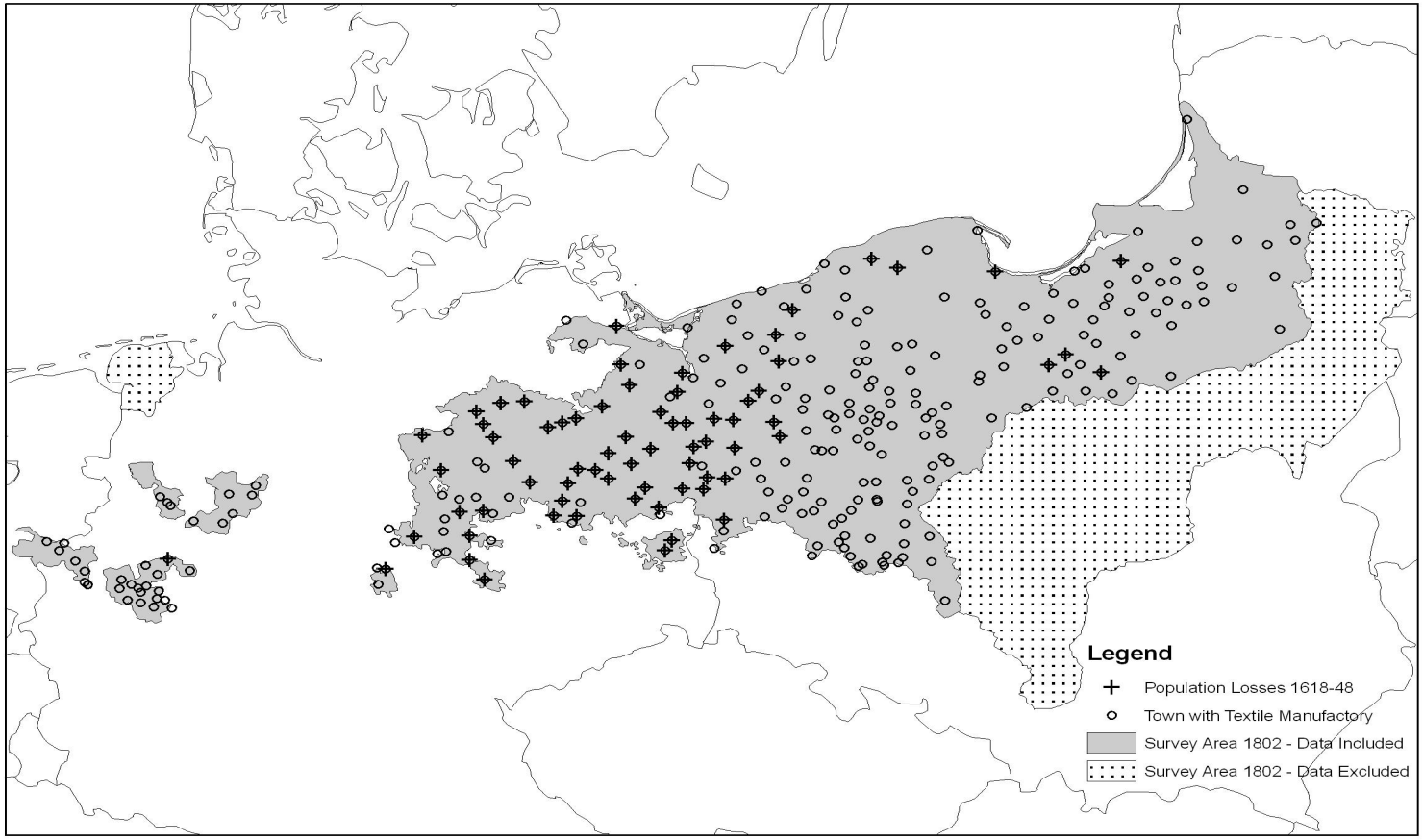

The Map shows the territory of Brandenburg-Prussia at the time of the Edict of Potsdam in 1685. Urban Huguenot colonies that were founded after 1685 are marked by a cross. Source: Own illustration; see main text for details.

Figure 2: Towns with Textile Manufactories in Prussia, 1802




The Map shows the Prussian territory that was included in the survey in 1802. Spotted areas are excluded from our analysis. Towns with at least one textile manufactory are marked with a circle. Urban Huguenot colonies that were founded after 1685 are marked by a cross. Source: Own illustration; see main text for details.

Figure 3: Availability of Data on Population Losses during the Thirty Years' War'




The Map shows the Prussian territory that was included in the survey in 1802. Spotted areas are excluded from our analysis. Towns with at least one textile manufactory are marked with a circle. Towns for which population losses during the Thirty Years' War are known are marked with a plus. Source: Own illustration; see main text for details.

Table 1: Descriptive Statistics

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| (ln) Output per worker | 5.032 | 0.849 | 1.951 | 7.536 | 693 |
| (ln) Value of materials per worker | 4.470 | 0.947 | 0.887 | 7.271 | 693 |
| (ln) Looms per worker | -1.146 | 1.296 | -7.005 | 0.560 | 693 |
| (ln) Workers | 2.963 | 1.684 | 0 | 8.534 | 693 |
| % Huguenots 1700 | 0.011 | 0.044 | 0 | 0.280 | 693 |
| % Huguenots 1720 | 0.009 | 0.029 | 0 | 0.151 | 693 |
| % Huguenots 1795 | 0.005 | 0.016 | 0 | 0.129 | 693 |
| (ln) Huguenots in textiles 1700 | 0.425 | 1.248 | 0 | 6.047 | 693 |
| (ln) Town population 1802 | 7.991 | 0.996 | 5.746 | 11.939 | 693 |
| Merino sheep p.c. 1816 (county) | 0.068 | 0.111 | 0 | 0.847 | 693 |
| % Protestant | 0.751 | 0.295 | 0.020 | 0.999 | 693 |
| Not Prussia in 1720 (dummy) | 0.348 | 0.477 | 0 | 1 | 693 |
| Population losses in 30 Years' War | 0.524 | 0.330 | -0.591 | 0.925 | 186 |

Source: 1802 textile manufactories data taken from Krug (1805). Huguenot data taken from Muret (1885) and GStA PK (1720). All other data taken from Mützell (1823-1825), except for Population losses in 30 Years' War (see Appendix C for sources and construction of this variable). Missing data in the variable Value of materials per worker are imputed (see Appendix B for methodology). Output and Value of materials are measured in Prussian Thalers from 1802.

Table 2: Huguenot Population Share and Productivity in Textile Manufactories in Prussia, 1802

| DepVar: (ln) Output per Worker | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| % Huguenots 1700 | 2.884*** | 1.382*** | 1.352*** | 1.440*** | 1.411*** |
| | (0.666) | (0.088) | (0.156) | (0.171) | (0.206) |
| (ln) Value of materials per worker | | 0.800*** | 0.800*** | 0.801*** | 0.800*** |
| | | (0.021) | (0.022) | (0.022) | (0.022) |
| (ln) Looms per worker | | 0.062*** | 0.063*** | 0.062*** | 0.062*** |
| | | (0.014) | (0.015) | (0.015) | (0.015) |
| Not using looms (dummy) | | 0.231*** | 0.233*** | 0.235*** | 0.235*** |
| | | (0.039) | (0.040) | (0.039) | (0.040) |
| (ln) Town population 1802 | | | 0.003 | 0.002 | 0.002 |
| | | | (0.015) | (0.016) | (0.016) |
| Merino sheep p.c. 1816 (county) | | | 0.093 | 0.103 | 0.104 |
| | | | (0.186) | (0.191) | (0.191) |
| % Protestant | | | | 0.074 | 0.073 |
| | | | | (0.084) | (0.084) |
| Not Prussia in 1700 (dummy) | | | | 0.071 | 0.071 |
| | | | | (0.048) | (0.049) |
| Relevant textile production before 1685 (dummy) | | | | | 0.010 |
| | | | | | (0.048) |
| Dummy for imputed values | | -0.002 | -0.003 | 0.006 | 0.004 |
| | | (0.035) | (0.036) | (0.037) | (0.037) |
| Constant | 5.001*** | 1.442*** | 1.413*** | 1.328*** | 1.333*** |
| | (0.041) | (0.110) | (0.143) | (0.136) | (0.138) |
| Observations | 693 | 693 | 693 | 693 | 693 |
| Number of towns | 302 | 302 | 302 | 302 | 302 |
| R-squared | 0.02 | 0.84 | 0.84 | 0.85 | 0.85 |

Notes: Table shows OLS estimates at the firm level. Standard errors, clustered at the town level, in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. See main text for data sources and details.

Table 3: Alternative Measures of the Huguenot Share

| DepVar: (ln) Output per Worker | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| % Huguenots 1700 | | | | | 1.851*** |
| | | | | | (0.454) |
| % Huguenots 1720 | 1.839*** | | | | -1.226 |
| | (0.605) | | | | (1.037) |
| % Huguenots 1795 | | 1.109 | | | -0.155 |
| | | (0.936) | | | (0.990) |
| (ln) Huguenots in textiles 1700 | | | 0.045** | | -0.006 |
| | | | (0.018) | | (0.022) |
| Huguenots 1700 dummy | | | | 0.135** | 0.103* |
| | | | | (0.055) | (0.062) |
| Additional controls | yes | yes | yes | yes | yes |
| Observations | 693 | 693 | 693 | 693 | 693 |
| Number of towns | 302 | 302 | 302 | 302 | 302 |
| R-squared | 0.84 | 0.84 | 0.84 | 0.84 | 0.85 |

Notes: Table shows OLS estimates at the firm level. Standard errors, clustered at the town level, in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Additional controls: Value of materials per worker, looms per worker, dummy for not using any looms, town population 1802, sheep per capita, share of Protestants, dummy for towns not in Prussia 1720, dummy for towns with relevant textile production before 1685, a dummy for imputed values, and a constant. See main text for data sources and details.

Table 4: Instrumenting the Huguenot Population Share with Population Losses during the Thirty Years' War

| | OLS | | IV | | | |
|---|---|---|---|---|---|---|
| DepVar: | (ln) Output per Worker | | % Huguenots 1700 | (ln) Output per worker | (ln) Huguenots in textiles 1700 | (ln) Output per worker |
| | Small Sample | Reduced Form | 1st Stage | 2nd stage | 1st Stage | 2nd stage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| % Huguenots 1700 | 1.582*** | | | 1.801** | | |
| | (0.298) | | | (0.883) | | |
| (ln) Huguenots in textiles 1700 | | | | | | 0.078** |
| | | | | | | (0.038) |
| Population losses in 30 Years' War | | 0.182* | 0.101** | | 2.321*** | |
| | | (0.098) | (0.042) | | (0.592) | |
| (ln) Value of materials per worker | 0.791*** | 0.790*** | -0.001 | 0.791*** | 0.075 | 0.784*** |
| | (0.039) | (0.041) | (0.004) | (0.038) | (0.125) | (0.036) |
| (ln) Looms per worker | 0.109*** | 0.127*** | 0.012** | 0.106*** | 0.111 | 0.119*** |
| | (0.029) | (0.030) | (0.006) | (0.029) | (0.144) | (0.024) |
| Not using looms (dummy) | 0.359*** | 0.390*** | 0.019** | 0.355*** | 0.398** | 0.359*** |
| | (0.070) | (0.074) | (0.010) | (0.069) | (0.193) | (0.068) |
| Relevant textile production | 0.146* | 0.145* | 0.003 | 0.140* | -0.368 | 0.174** |
| before 1685 (dummy) | (0.076) | (0.082) | (0.020) | (0.076) | (0.368) | (0.080) |
| Additional controls | yes | yes | yes | yes | yes | yes |
| Observations | 186 | 186 | 186 | 186 | 186 | 186 |
| Number of towns | 71 | 71 | 71 | 71 | 71 | 71 |
| R-squared | 0.89 | 0.88 | 0.61 | 0.89 | 0.75 | 0.89 |
| Kleibergen-Paap F statistic | | | | 5.749 | | 15.39 |

Notes: Columns 1-2 show OLS estimates at the firm level. Columns 3-6 show the first and second stage estimates of an IV approach where population losses in the Thirty Years' War serve as an instrument. Sample: Towns with available data for the instrument. Standard errors, clustered at the town level, in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Additional controls: Town population 1802, sheep per capita, share of Protestants, dummy for towns not in Prussia 1720, a dummy for imputed values, and a constant. See main text for data sources and details.

Table 5: Huguenot Population Share and Productivity in Different Textile Manufactories

| DepVar: (ln) Output per Worker | Wool (1) | Linen (2) | Cotton (3) | Silk (4) |
|---|---|---|---|---|
| % Huguenots 1700 | 0.706*** | 3.102*** | 1.967* | 1.699*** |
| | (0.243) | (0.503) | (1.035) | (0.549) |
| (ln) Value of materials per worker | 0.818*** | 0.774*** | 0.744*** | 0.834*** |
| | (0.028) | (0.038) | (0.143) | (0.024) |
| (ln) Looms per worker | 0.086*** | 0.022 | -0.011 | 0.495*** |
| | (0.017) | (0.079) | (0.128) | (0.066) |
| Not using looms (dummy) | 0.257*** | 0.168 | 0.053 | 1.289*** |
| | (0.040) | (0.362) | (0.746) | (0.171) |
| Additional controls | yes | yes | yes | yes |
| Observations | 521 | 123 | 27 | 22 |
| Number of towns | 272 | 111 | 27 | 15 |
| R-squared | 0.84 | 0.88 | 0.89 | 0.99 |

Notes: Table shows OLS estimates at the firm level. Standard errors, clustered at the town level, in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Additional controls: Town population 1802, sheep per capita, share of Protestants, dummy for towns not in Prussia 1720, a dummy for imputed values, and a constant. See main text for data sources and details.

Table 6: Huguenot Population Share and Productivity in Different Non-Textile Manufactories

| DepVar: (ln) Output per Worker | (1) Non-textile | (2) Leather | (3) Metal | (4) Tobacco | (5) Flour mills | (6) Misc. |
|---|---|---|---|---|---|---|
| % Huguenots 1700 | 0.415 | -0.856 | 0.287 | 0.567 | 1.702 | -0.013 |
| | (0.336) | (0.597) | (0.562) | (0.529) | (1.437) | (0.697) |
| (ln) Value of materials per worker | 0.813*** | 0.826*** | 0.822*** | 0.849*** | 0.880*** | 0.592*** |
| | (0.019) | (0.023) | (0.039) | (0.081) | (0.060) | (0.109) |
| Additional controls | yes | yes | yes | yes | yes | yes |
| Observations | 695 | 371 | 80 | 43 | 32 | 78 |
| Number of towns | 250 | 216 | 42 | 41 | 24 | 34 |
| R-squared | 0.89 | 0.89 | 0.95 | 0.90 | 0.97 | 0.72 |

Notes: Table shows OLS estimates at the firm level. Standard errors, clustered at the town level, in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Additional controls: Town population 1802, sheep per capita, share of Protestants, dummy for towns not in Prussia 1720, a dummy for imputed values, and a constant. See main text for data sources and details.

Table 7: Exogeneity of the Instrument

| | Indicators of pre-War development | | |
|---|---|---|---|
| | (ln) City size | On Hanseatic trade route | Year city rights documented |
| | (1) | (2) | (3) |
| Population losses in 30 Years' War | -0.0061 | 0.0246 | -0.0004 |
| | (0.0322) | (0.0169) | (0.0004) |
| Observations | 68 | 69 | 69 |
| R-squared | 0.0005 | 0.031 | 0.013 |

Notes: Table shows OLS estimates at the town level. Standard errors in parentheses. Constant not reported. Significance: *** p<0.01, ** p<0.05, * p<0.1. See main text for data sources and details.

# Appendix A Excerpt from the Edict of Potsdam

**Article 3**

German original

Weilen Unsere Lande nicht allein mit allen zu des Lebens Unterhalt erforderten Nothwendigkeiten wol und reichlich versehen, sondern auch zu établirung allerhand Manufacturen, Handel und Wandels zu Wasser und zu Lande sehr bequem, als stellen Wir denen, die darinn sich werden setzen wollen, allerdings frey, denjenigen Ort, welchen sie in Unserm Herzogthum Cleve, den Graffschafften Marck und Ravensberg, Fürstenthümern Halberstadt und Minden, oder auch in dem Herzogthum Magdeburg, Chur-Marck-Brandenburg und Herzogthümern Pommern und Preussen zu ihrer Profesion und Lebens Art am bequemsten finden werden, zu erwählen; Und gleichwie Wir dafür halten daß in gedachter Unserer Chur-Marck-Brandenburg die Städte Stendal, Werben, Rathenow, Brandenburg und Franckfurt und in dem Herzogthum Magdeburg die Städte Magdeburg, Halle und Calbe, wie auch in Preußen die Stadt Königsberg, so wol deßhalb weil daselbst sehr wolfeil zu leben als auch wegen der allda sich befindenden facilität zur Nahrung und Gewerb vor sie am bequemsten seyn werden Als haben Wir die Anstalt machen lassen befehlen auch hiemit und Krafft dieses so bald einige von erwehnten Evangelisch-Reformierten Französischen Leuten daselbst ankommen werden daß alßdan dieselben wol auffgenommen und zu allemdem so zu ihrem établissement nöthig ihnen aller Müglichkeit nach verholffen werden soll.

English translation

Because our country is convenient with everything one needs for a living and for establishment of manufactories, trade and commerce by water and land we make available for those who want to settle at whichever place they find in Our Duchy of Cleves, the Counties of Mark and Ravensberg, Principalities of Halberstadt and Minden or in the Duchy of Magdeburg, the Margraviate of Brandenburg and the Duchies of Pomerania and Prussia convenient for their profession and lifestyle; Although we recommend the cities Stendal, Werben, Rathenow, Brandenburg and Frankfurt in Our Margraviate of Brandenburg, Magedeburg, Halle and Calbe in the Duchy of Magdeburg, as well as the city of Königsberg in Prussia because they are most comfortable to live in as well as there is enough facility for food and craft and We already ordered and hereby command that as soon as some of the mentioned evangelic-reformed French people arrive, that they shall be accommodated and given everything needed and possible for their establishment (Own translation).

# Appendix B Productivity Data and Imputation

The firm-level data used in this work was taken from the "Register of Factories in the Prussian State" conducted by the Prussian Royal Secret Filing Department in 1802 (Krug, 1805, pp. 219-381). The information was collected by inspectors who annually surveyed all manufactories in their area of responsibility and had to send in standardized and printed tables with the requested information on type, location, number of workers, number of looms, value of raw materials used, and value of production in Prussian Thalers. Manufactories are classified by their main input material into 19 categories (wool, linen, cotton, silk, leather, metals, oil-, groat- , and cutting mills, paper mills, tobacco, sugar, glass, soap, powder, earthenware, vinegar, wax, and miscellaneous). After we excluded manufactories in areas not belonging to Prussia after 1807 and in rural areas, textiles amount to 693 observations and non-textiles amount to 695 observations.

Historical records often suffer from missing data for reasons unknown and irreparable. The only category used in our empirical analysis which is missing data is the value of raw materials, where missings amount to 14 percent of observations. While the mechanism

generating the missing data is unknown, we are able to observe a geographical pattern. Almost every province is missing few (2-5) observations, the exception being the provinces *Kurmark* and *Littauensches Department*, where all observations are missing. We assume that the assigned inspectors simply did not collect or report this information. This would imply that the values of the missing observations are not dependent on the value of the variable itself but on the location. Dropping all observations with missing data would reduce the sample size severely and introduce bias if the remaining observations are not representative of the full population of interest. This makes imputational methods the first choice to address the problem (Rubin, 1987; Little and Rubin, 2002).

We impute the missing data using univariate multiple imputation methods for continuous variables, integrated in Stata 11 (StataCorp, 2009). To attain a complete dataset, we impute missing data in the explanatory variable "Value of Materials" with all other variables used for the extensive regression in column 5 of Table 2, the value of outputs, the number of workers, the number of looms, the share of Huguenots, the town population, sheep per capita, the share of Protestants and a dummy for towns not belonging to Prussia before 1720.

Since the process that generated the missing values is unknown, the probability to have a missing value might depend on unobserved characteristics not included in the imputation. These unobservables again might influence output of the manufactory systematically. In such a case we would predict identical values for manufactories with identical observed but possibly different unobserved characteristics and bias the estimates in an unknown direction.

To make sure our estimates are not driven by imputed data, we include an imputation dummy in all of our regressions. The dummy becomes 1 if data on the value of raw materials used were originally missing for the observation.

## Appendix C Population Loss Data and Construction of the Instrument

We compiled a database on population losses during the Thirty Years' War for those towns with textile manufactories in 1802. The data were assembled from three different sources, each providing a consistent overview over a certain area.

The most extensive source is the *Deutsches Städtebuch* (Handbook of German Towns) by Keyser (1939-1941). The compendium provides information for all German towns and includes data on population for various points in time. To calculate the population losses during the war period, we would ideally need population data for the years 1625 (Brandenburg did not enter the war until 1626) and 1652, which are the breaks also used

in other sources (Wohlfeil, 1976). Unfortunately, information about town population for the period in question is very rare and data for these exact years is even more scarce.

When available, we used data as close as possible to said years and interpolated them to match the beginning and the end of the war. The earliest date used is 1550 and the latest date is 1685. The interpolation was undertaken using population growth rates for Germany calculated in Pfister (2007).

Table C-1: Population Growth in Germany (1914).

| Period | Growth Rate |
|---|---|
| 1541-1550 | 7.2 |
| 1551-1560 | 7.1 |
| 1561-1570 | 5.8 |
| 1571-1580 | 4.6 |
| 1581-1590 | 4.1 |
| 1691-1600 | 3.2 |
| 1601-1625 | 3.2 |
| 1626-1650 | -13.4 |
| 1651-1700 | 8-10 |

Growth rate in per mil calculated after Pfister (2007, p. 10)

For example, if a town had a population of 1000 in the year 1600, we use the growth rates to estimate a population of 1080 in 1625. If the population had reached 700 in 1660, we estimate a population of 650 in 1652. The population loss would thus be 40%, instead of 30% if we do not interpolate.

We only included towns if information on the number of residents, households, fireplaces or citizen was available both before and after the war. Finally we used only those pieces of information where the unit of observation was the same for both dates. Cases which, for example, reported the number of houses in a town before the war and the number of fireplaces after the war, were excluded. Comparability between towns with different units of observation is granted since we calculated growth rates. A total of 57 towns matched the criteria for inclusion. Interpolation increases the power of the instrument (F-test increases from 4.1 to 5.7). However, using the original data does not affect the results substantially.

The second source is a map by Wohlfeil (1976) showing the percentage of population losses in towns during the Thirty Years' War in the Margraviate of Brandenburg between 1625 and 1652/53. A total of 46 towns matched the criteria for inclusion.

The third source is a population table for towns in the *Kurmark* and the *Neumark* before and after the Thirty Years' War, published in Behre (1905). Here the number of residents is given for 1625 and 1645. A total of 37 towns matched the criteria for inclusion.

In total, we gathered information for a total of 71 different towns for which we also had data on textile manufactories and Huguenot immigration. If information for the same town was available from different sources, we calculated the mean to level possible measurement error.

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